A Working Plan for the Del Monte Forest of the Pacific Improvement Company

By

Duncan Dunning

B.S.1915

THESIS

Submitted in partial satisfaction of the requirements for the degree of

MASTER OF SCIENCE

in

Forestry

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA

May, 1916

The map accompanying this Thesis is placed in map closet B26

Approved D T Mason
Instructor in Charge

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A Working Plan for the Del Monte Forest of the Pacific

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MAP

Type Map of the Del Monte Forest	79

PRELIMINARY SUMMARY

Del Monte Forest

Total wood-producing area — 4097 acres.

Total present volume of merchantable green timber — 54,000 cords, or 28,000,000 feet B.M.

Present annual growth — 3900 cords.

Present average annual cut — 700 cords (1500 short cords).

Recommendations

Build up the cord-wood market; at present it is estimated that 1500 cords a year can be disposed of locally.

Increase the annual cut to 2500 cords for the next ten years.

Cut for wood only in such a way as not to reduce the aesthetic value of the forest along drives and about residence sections.

PRELIMINARY SUMMARY

Del Monte Forest

Total wood-producing area — 4037 acres.

Total present volume of merchantable green timber — 34,000 cords, or 28,000,000 feet B.M.

Present annual growth — 3900 cords.

Present average annual cut — 700 cords (1300 short cords).

Recommendations

Build up the cord-wood market; at present it is estimated that 1500 cords a year can be disposed of locally.

Increase the annual cut to 2500 cords for the next ten years.

Cut for wood only in such a way as not to reduce the aesthetic value of the forest along drives and about residence sections.

A WORKING PLAN FOR THE DEL MONTE FOREST OF THE PACIFIC IMPROVEMENT COMPANY

1916

Introduction

The Del Monte Forest, aside from its great popular and scientific interest, has several characteristics which especially adapt it for the practice of forestry. It is situated adjacent to a considerable market for the product — cordwood; it is essentially a pure forest of a species which may be grown on a short rotation — Monterey pine (Pinus radiata Don.); an extensive system of roadways makes every part of the forest accessible; a large part of the area is chiefly valuable for wood production, or for the aesthetic properties of the forest cover.

Realizing the possibilities of the tract and the value of a systematic plan of forest management, the Pacific Improvement Company agreed to have the author do the necessary field work and prepare the working plan as a subject for this thesis, with the approval of the Division of Forestry of the University of California.

This plan, if adopted, owing to the brief time allowed for the securing of data on which it is based and to changing conditions, should be revised after ten years where experience suggests improvement.

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This plan, it adopted, owing to the brief time allowed for the securing of data on which it is based and to changing conditions, should be revised after ten years where experience suggests improvement.

During the work a number of problems of scientific interest developed, such as the excessive cone bearing of young Bishop Pine and the development of secondary branch whorls and false growth rings in Monterey Pine, without apparent relation to growing conditions. A discussion of these subjects would be out of place here.

During the preparation of this plan, much valuable assistance and information was given by officials and employees of the Pacific Improvement Company and the Monterey County Water Works. The District Office of the U. S. Forest Service, in San Francisco, gave permission to use a report on the Monterey Pine. Dr. E. P. Meinecke, Pathologist of the U. S. Bureau of Plant Industry, identified some specimens of fungi. Dr. E. C. Van Dyke, of the University of California, identified several insect specimens. Mr. G. A. Coleman, also of the University of California, has kindly given permission to take certain data, relating to insect control and a list of grasses, from a typewritten paper on the region under consideration.

Assistant Professor Donald Bruce and Professor D. T. Mason, of the Division of Forestry of the University of California, have given valuable assistance and advice, for which the writer is very grateful.

PART I

GENERAL DESCRIPTION

---

1. Location and Area

The Del Monte Forest, owned by the Pacific Improvement Company of San Francisco, occupies the greater part of the Monterey peninsula in Monterey County, California, adjoining the cities of Monterey and Pacific Grove on the south and west. The forest comprises a single parcel, all parts of which are within five miles in a direct line from the center of Monterey. Portions of the tract along the borders are, from time to time, subdivided and sold in small lots. The forest originally occupied a considerable part of the present site of Pacific Grove.

The land was acquired by the Company in 1878. It consists of portions of the old Spanish ranches — Point Pinos and El Pescadero. Early owners grazed the land, as is evidenced by many sharply defined grassy openings, and previous to 1896 heavy unregulated cutting was practiced.

The area to which this plan specifically applies is approximately 5,638 acres. The boundaries are indicated on the accompanying map. A deduction of 26.2 acres is made for Clay Pits reservoir site. The Pebble Beach subdivision and land owned by the Company within the city limits of Pacific Grove are not included,

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since the small amount of timber on these tracts has a far greater aesthetic than commercial value.

2. Physiographic Features

a. Climate.— The climate of the Monterey peninsula is very mild. There is a range of temperatures between the average maximum and average minimum of less than 12°F. The mean annual temperature for 50 years at Monterey is 56.4°F. (U.S. Weather Bureau, 1915). The average maximum temperature, 61.9°F., occurs in August, the average minimum, 50.2°F., in January. The maximum temperature is 80°F., the lowest 30°F.

The average annual precipitation since 1899 is shown by records of the Monterey County Water Works, taken at Clay Pits reservoir in the center of the tract, to be 18.13 inches, the maximum being 29.66 inches, and the minimum 10.19 inches. The heaviest rains occur from December 1st to April 1st. The last important rain in spring usually falls before May 15th. There is usually no rain during July and August, but heavy fogs during May, June, July, and August prevent excessive drought until seedlings are well established. September and October, being without fog and with little rain, are the months of greatest fire danger. The prevailing winds are from the west. Periodic severe windstorms during the early spring

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3. Physiographic Features

a. Climate.— The climate of the Monterey peninsula is very mild.
There is a range of temperature between the average
maximum and average minimum of less than 15°F. The mean
annual temperature for 50 years at Monterey is 56.4°F.
(U.S. Weather Bureau, 1918). The average maximum
temperature, 61.8°F., occurs in August, the average
minimum, 50.9°F., in January. The maximum temperature
is 99°F., the lowest 30°F.

The average annual precipitation since 1849 is shown
by records of the Monterey County Water Works, taken at
Clay Pike reservoir in the center of the tract, to be 18.13
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10.19 inches. The heaviest rains occur from December
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seedlings are well established. September and October,
being without fog and with little rain, are the months of
greatest fire danger. The prevailing winds are from the
west. Periodic severe windstorms during the early spring

months are an important factor in dealing with the shallow rooted Monterey pine.

The long growing season, the high relative humidity of the air, and summer fogs during the growing period in the immediate vicinity of the forest, account for the remarkable growth of Monterey pine, which the scanty rainfall would not otherwise support.

Table I — Climatological Data

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Max. Ann.	Min. Ann.	Mean Ann.
Average monthly Precipitation — Inches — 1899-1915*														
4.08	2.79	3.70	1.15	0.75	0.13	0.002	0.001	0.36	0.79	1.71	2.67	29.66	10.19	18.13
Average monthly Temperatures — Degrees F. — 50 yrs.#												Max. daily	Min. daily	Mean Ann.
50.2	51.2	53.9	55.8	58.3	60.8	60.0	61.9	61.5	58.2	54.3	51.7	80	30	56.4

*Records of the Monterey County Water Works, taken at Clay Pits reservoir. Does not include 1909.

#U. S. Weather Bureau Records for Monterey. Length of records, 50 yrs.

b. Topography.— The Monterey peninsula extends out from the mainland about four miles, between Carmel and Monterey Bays, and is from 3½ to about 5 miles in width. The coast line is generally irregular and broken by rocky points. The central backbone, or ridge, reaches its highest point,

b. Topography.— The Monterey peninsula extends out from the mainland about four miles, between Carmel and Monterey Bays, and is from 3½ to about 5 miles in width. The coast line is generally irregular and broken by rocky points. The central backbone, or ridge, reaches its highest point,

Table I — Climatological Data

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Min. Ann.	Mean Ann.
Average monthly Precipitation -- Inches -- 1899-1929														
4.06	2.79	3.70	1.15	0.73	0.13	0.02	0.001	0.36		0.79	1.71	3.67	29.86	19.19	18.12
Average monthly Temperature -- Degrees F. -- 30 yrs.													Max. daily	Min. daily	Mean Ann.
50.3	51.2	52.9	55.6	58.3	60.9	63.0	64.0	63.8	61.9	58.2	54.3	51.7	69	30	56.4

*Records of the Monterey County Water Works, taken at Clay Pike reservoir. Does not include 1930.

½. Weather Bureau Records for Monterey. Length of records, 30 yrs.

months are an important factor in dealing with the shallow rooted Monterey pine.

The long growing season, the high relative humidity of the air, and summer fogs during the growing period in the immediate vicinity of the forest, account for the remarkable growth of Monterey pine, which the county rainfall would not otherwise support.

about 800 ft. above the sea, near the eastern boundary of Rancho El Pescadero. The slope from this point toward the north and south is quite steep, this being the most rugged part of the tract. Toward the west and northwest the slope to the ocean is very gradual, being somewhat broken in the upper portion by the gulches of Sawmill and Seal Rock Creeks. For a considerable distance back from the shore on the west and northwest, the surface is very even. From Carmel Hill, Pescadero Creek runs southward through a steep canon to Carmel Bay. Near the beach on the southwest, at Pt. Douty, there is a sudden rise to an elevation of 250 ft. The streams are all intermittent in character and no permanent springs exist on the tract. Clay Pits reservoir, to which water is brought by pipe line, supplies the peninsula with water.

Beginning just south of the Pt. Pinos light-house, a series of sand dunes follows the beach to Sawmill Creek, extending inland from one to two thousand feet, ending in abrupt slopes at the edge of the forest. A second series occurs between Seal Rock Creek and Cypress Point, and stretches inland nearly half a mile. Except in a few places, these dunes are well fixed by shrubs and

about 800 ft. above the sea, near the eastern boundary of Rancho El Rancadero. The slope from this point toward the north and south is quite steep, this being the most rugged part of the trail. Toward the west and northwest the slope to the ocean is very gradual, being somewhat broken in the upper portion by the gulches of Sawmill and Coal Back Creeks. For a considerable distance back from the shore on the west and northwest, the surface is very even. From Carmel Hill, Rancadero Creek runs southward through a sandy canon to Carmel Bay. Near the beach on the southwest, at Pt. Bonita, there is a sudden rise to an elevation of 300 ft. The streams are all intermittent in character and no permanent springs exist on the trail. Clay pipe reservoir, to which water is brought by pipe line, supplies the peninsula with water.

Beginning just south of the Pt. Pinos Light-house, a series of sand dunes follows the beach to Sawmill Creek, extending inland from one to two thousand feet, ending in abrupt slopes at the edge of the terrace. A second series occurs between Coal Back Creek and Cypress Point, and advances inland nearly half a mile. Except in a few places, these dunes are well fixed by shrubs and

stunted trees, and are encroaching on the forest only very slowly.

In general, the surface is smooth and firm, with few rock outcroppings, and with few exceptions, all parts of the tract may be easily reached by wood roads. Because of the sandy soils, these roads become badly cut by running water.

c. Geology and Soils.— The principal rocks of the peninsula belong to four general groups — granites, basalts, sandstones, and shales. The granite is the most abundant and is responsible for the central ridge and the rocky points along the coast line. Its composition varies greatly, but the percentage of feldspar is usually high. When exposed, the granite rapidly disintegrates, and much of the soil is light and gravelly in character. Sandstone and Monterey shale appear throughout the area. In the region of Huckleberry Hill, beds of sandstone are quite near the surface and account for poor tree growth there. The basalt appears in a great dyke, extending from a point near Chinese Cove back toward Carmel Hill,* and appears in Pescadero Canon. Deposits of diatomaceous earth occur to the eastward. The sand of the dunes is nearly pure white silica.

*The name Carmel Hill is used here to distinguish the point northeast of the Carmel Hill Gate from that on the opposite side of the county road, or Huckleberry Hill.

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There is a considerable variety of soils. The best soil, a deep fine sandy loam, lies in a belt from one half to one mile in width along the lower slopes, inside the sand hills. This soil supports the best tree growth. On the upper slopes the soils are shallower and of coarser texture, for the most part gravelly and sandy clays. On the slopes to the south and west of Huckleberry Hill, the soil is sandy and often quite shallow. On the steeper slopes in this region, the trees often give way to brush areas. South of the reservoir there is considerable clay, and here the soil is apt to bake. Except in a few places, even the poorer soils support a fair growth of pines.

d. Market, Social, and Industrial Conditions.— The total population of the Monterey peninsula, as shown by census reports and the records of the Monterey County Water Company, is approximately 10,000, considering only the average of permanent residents. Practically the whole population is centered in the towns. There is a considerable summer tourist population. In 1914 the population by districts was as follows:

Monterey	5,000
Pacific Grove	2,500
U.S. mil. Presidio	1,200
Del Monte	500
Carmel	500
Pebble Beach and outlying	300
Total	10,000

There is a considerable variety of soils. The best soil, a deep fine sandy loam, lies in a belt from one half to one mile in width along the lower slopes, inside the sand hills. This soil supports the best tree growth. In the higher places the soils are shallower and of coarser texture, for the most part gravelly and sandy clays. On the slope to the south and west of Huckleberry Hill, the soil is sandy and often quite shallow. On the steeper slopes in this region, the trees often give way to brush areas. South of the reservoir there is considerable clay, and here the soil is apt to bake. Except in a few places, even the poorer soils support a fair growth of pines.

d. Density, Social, and Industrial Conditions.— The total population of the Monterey peninsula, as shown by census reports and the records of the Monterey County Water Company, is approximately 10,000, considering only the average of permanent residents. Practically the whole population is centered in the towns. There is a considerable summer tourist population. In 1914 the population by districts was as follows:

Monterey	5,000
Pacific Grove	3,500
U.S. mil. Presidio	1,200
Del Monte	300
Carmel	300
Pebble Beach and outlying	300
Total	10,000

The number of families and other units, or probable users of fuel, may be summarized as follows for December 31, 1915:

Pacific Grove		1,656
Monterey		1,503
Carmel		407
Other places		72
	Total	3,638

Several years ago many of these utilities were very heavy users of pine wood and provided an excellent market. The Hotel Del Monte and baths and other hotels now use oil fuel largely. The Presidio of Monterey formerly contracted annually for 3,000 cords, but has recently begun using live oak wood from the Carmel Valley. Coal and fuel oil are burned to some extent.

There is considerable competition for the wood market. The David Jacks Corporation owns timber land adjoining, equal in area to that of the Del Monte Forest. Tracts of land sold for residence sites are often cleared and the wood sold. Oak wood is delivered in Monterey from the Carmel Valley at a selling price of about one dollar per cord more than pine sells for.

After years of experience, the Company's Superintendent of roads and forest believes that from 2,000 to 3,000

The number of families and other units, or probable users of fuel, may be summarized as follows for December 31, 1915:

Pacific Grove	1,852
Monterey	1,302
Carmel	497
Other places	73
Total	3,924

Several years ago many of these utilities were very lucky users of plum wood and provided an excellent market. The Hotel Del Monte and baths and other hotels now use oil fuel entirely. The Presidio of Monterey formerly consumed annually for 3,000 cords, but has recently begun using live oak wood from the Carmel Valley. Coal and fuel oil are burned in some ovens.

There is a considerable competition for the wood market. The Naval Powder Corporation owns timber land adjoining, equal in area to that of the Del Monte Forest. Tracts of land sold for residence sites are often cleared and the wood sold. Oak wood is delivered in Monterey from the Carmel Valley at a selling price of about one dollar per cord more than pine sells for.

After years of experience, the Company's Superintendent of roads and forest believes that from 2,000 to 3,000

California cords* may be locally disposed of annually.

As to the possibility of shipment, the tracks of the Southern Pacific Railroad extend into the forest at the northwest corner, where a favorable loading place is offered. The distance to San Francisco is about 124 miles. The freight expense would be about $3.00 per cord. Wholesale wood dealers in San Francisco pay $4.00 to $4.50 per cord for pine wood, f.o.b. shipping point. At the present time the wood market in that city is rather poor, owing, partly, to the cheap supply obtainable from wreckage at the Exposition Grounds. The subject of market, including the relative value of substitutes for wood now being used locally, should be further investigated.

e. Transportation.— The Southern Pacific Railroad extends into the forest at the northwest corner. A right of way for the extension of this railroad through the forest to Carmel was surveyed and cleared several years ago, but the extension will probably not be made soon. A system of excellent roads traverses the area. Several roadways have been cleared, and old wood roads extend to all parts of the tract. These are grown up to some extent, but can easily be made usable. (See map.)

---

* About 1200 to 1700 ordinary cords. A California cord consists of two tiers of 14-inch wood, 4 feet high, and 8 feet long. A recent law passed by the State Legislature requires 128 cubic feet to the cord.

California cords may be locally disposed of annually.

As to the possibility of shipment, the tracks of the Southern Pacific Railroad extend into the forest at the northwest corner, where a favorable loading place is offered. The distance to San Francisco is about 136 miles. The freight expense would be about $3.00 per cord. Firewood would therefore in San Francisco pay $4.00 to $4.50 per cord for mine wood, f.o.c. shipping point. At the present time the wood market in that city is rather poor, owing, partly, to the cheap supply obtainable from wreckage at the Exposition Grounds. The subject of market, including the relative value of substitutes for wood now being used locally, should be further investigated.

4. Transportation.— The Southern Pacific Railroad extends into the forest at the northwest corner. A right of way for the extension of this railroad through the forest to Carmel was surveyed and cleared several years ago, but the extension will probably not be made soon. A system of excellent roads traverses the area. Several roadways have been cleared, and old wood roads extend to all parts of the tract. These are grown up to some extent, but can easily be made usable. (See map.)

---

* About 1200 to 1700 ordinary cords. A California cord consists of two piers of 14-inch wood, 4 feet high, and 8 feet long. A recent law passed by the State Legislature requires 128 cubic feet to the cord.

f. Land Classification.— There is little cultivated land on the Monterey peninsula. A large part of the area, outside of the cities of Monterey and Pacific Grove on the north and the residence districts of Carmel and Pebble Beach on the south, is covered with pine forests. In doing the reconnaissance work for this plan, the land was classified and the types surveyed and placed on the accompanying map. The area by types was then obtained with a planimeter.

Table II — Areas by Types

Type	Area in Acres
Total forested	4517.8
Grassy open land	550.5
Sand hills (barren)	415.4
Brush land	149.5
Administrative	4.8
Total	5638.0

These classes constitute the total area within the bounds indicated on the map, exclusive of 26.2 acres around Clay Pits reservoir. The total area of sand hills is about 498.2 acres, 82.8 acres of which is sparsely timbered. The administrative area consists of enclosures

These classes constitute the total area within the bounds indicated on the map, exclusive of 28.2 acres around Clay Pike reservoir. The total area of sand hills is about 498.2 acres, 82.8 acres of which is sparsely timbered. The administrative area consists of enclosures

at the gateways entering the forest and the opening in which the patrolman lives at the reservoir. The open land consists of a considerable grassy strip of 84 acres along the beach between Pt. Cypress and the sand hills, and a grassy plain of 248 acres along the beach from the mouth of Seal Rock Creek to the sand dunes at Sawmill Creek, together with many smaller grassy openings scattered through the forest, the most extensive of which appear on the south slope below the Carmel Hill gate.

PART II

THE FOREST

---

1. Forest Types

For purposes of management the forest area of 4517.8 acres may be treated by types according to the species predominating, as shown in Table III below.

Table III — Area of Forest Types (Acres)

Predominant Species							
Age yrs.	Monterey Pine	Age yrs.	Bishop Pine	Age yrs.	Monterey Cypress	Age yrs.	Gowan Cypress
1-20	1034.2	15	161.0*	all aged	97.8	1-15	2.3
21-40	255.4					50	1.8
41-60	1270.8						
Irreg.	1236.5						
Beach Protection Belt	158.0						
Totals	4254.9		161.0		97.8		4.1
Total forested — all species							4517.8
*Approximate area — see below.							

The Monterey pine is the only species of commercial importance. It will be considered in detail later.

THE FOREST

---

1. Forest Types

For purposes of management the forest area of 4317.8 acres may be treated by types according to the species predominating, as shown in Table III below.

Table III -- Area of Forest Types (Acres)

Age yrs.	Monterey Pine	Age yrs.	Bishop Pine	Age yrs.	Monterey Cypress	Age yrs.	Common Cypress
1-20	1034.3	15	161.0*	all aged	97.8	1-15	3.3
21-40	255.4					50	1.8
41-60	1270.3						
Irreg.	1339.3						
Beach protection							
Belt	139.3						
Totals	4304.3		161.0		97.8		4.1
"Approximate area -- see below.							
Total forested -- all species							4317.8

The Monterey pine is the only species of commercial importance. It will be considered in detail later.

a. Bishop Pine (Pinus muricata - Don.).— This species occurs in pure stands on the west slope of Huckleberry Hill. Scattered trees may be found, mixed with Monterey pine, over a much larger area than is indicated on the map, extending from the summit of Huckleberry Hill to a point just east of the reservoir. The species is confined to an area of about 1,000 acres, burned over by a fire in 1901, and all but a very few surviving trees are 14 to 15 years old. The soil here is shallow and gravelly, and the young stand is very dense; consequently the trees are very small, being only 5 to 15 feet high and mostly less than 1 inch in diameter at breast height. (See photograph, p. 18.)

The area of pure Bishop pine was sketched on the map by ridges and stream courses and from field notes taken at different points, so that the acreage given is only approximate. Owing to the density of the stand, an accurate survey would be very tedious and expensive. (For further discussion, see appendix.)

b. Monterey Cypress (Cupressus macrocarpa Hartw.).— This species, because of its peculiar history and picturesque beauty in its natural habitat, has attracted world-wide interest, and many erroneous assumptions have been made concerning it. Its aesthetic value is very important. On the Company's land it occupies a narrow strip, 500 to 1,000 feet wide, along the beach from Pt. Cypress to

a. Bishop Pine (Pinus muricata - Don.).— This species occurs in pure stands on the west slope of Huckleberry Hill. Scattered trees may be found, mixed with Monterey pine, over a much larger area than is indicated on the map, extending from the summit of Huckleberry Hill to a point just west of the reservoir. The species is confined to an area of about 1,000 acres. Burned over by a fire in 1901, and all but a very few surviving trees are 14 to 15 years old. The soil here is shaley and gravelly, and the young stand is very dense; consequently the trees are very small, being only 5 to 15 feet high and mostly less than 1 inch in diameter at breast height. (See photograph, p. 18.)

The area of pure Bishop pine was mapped on the map by ridges and stream courses and from field notes taken at different points, so that the acreage given is only approximate. Owing to the density of the stand, an accurate survey would be very tedious and expensive. (For further discussion, see appendix.)

b. Monterey Cypress (Cupressus macrocarpa Hartw.).— This species, because of its peculiar history and picturesque beauty in its natural habitat, has attracted world-wide interest, and many erroneous assumptions have been made concerning it. Its marketable value is very important. On the Company's land it occupies a narrow strip, 500 to 1,000 feet wide, along the beach from Pt. Cypress to

Monterey Cypress Type in which no cutting is done except to remove the debris of wind storms.

Gowan Cypress
(Cupressus goveniana Gord.)

Trees which survived the fire of 1901. (The compass staff is 4 ft. high.)

Bishop Pine.— Young trees on area burned over in 1901, 4 to 6 ft. in height, and 14 to 15 years old. Note cones on small trees. The seed which produced these trees came from charred cones such as those in the foreground.

Dense stand of young pines after the fire of 1901.

Banks Mound of young pines after the fire of 1902.

Pt. Pescadero. The total area is about 118.8 acres, 21.0 acres of which is in the Pebble Beach subdivision. There is a small amount of Monterey pine on the area as indicated on the map. (For further discussion, see appendix, p. 63.)

c. Gowan Cypress (Cupressus goveniana Gordon).— Gowan cypress occurs in small patches on the west slope of Huckleberry Hill, mixed with Bishop and Monterey pines on the burned area. Scattered trees are found almost to the reservoir. Two small areas, 4.1 acres, were placed on the map where this tree forms dense stands. One of these survived the fire of 1901. The trees there are only 10 to 15 feet high, the older ones being about 50 years old. The other area consists of mere switches that have come in since the fire. These tiny trees, often only 12 inches high, but 10 to 15 years old, bear cones in abundance. This type has no value other than the interest taken in the peculiarities of the species.

d. Monterey Pine (Pinus radiata Don.).— This is by far the most abundant species and the only one considered for wood production. The actual timbered area in this type, 4254.9 acres, excluding natural openings, has been subdivided for management by 20-year age classes and by quality of site. (See map.) Three site qualities are recognized, site I being the best, and site III the poorest. A summary is made in Table IV. The age of the

Pt. Pescadero. The total area is about 118.3 acres, 21.0 acres of which is in the Pebble Beach subdivision. There is a small remnant of Monterey pine on the area as indicated on the map. (For further discussion, see appendix, p. 65.)

c. Cuyamaca Cypress (Cupressus goveniana cuyamacensis).— Seven cypress occurs in small patches on the west slope of Huckleberry Hill, mixed with Bishop and Monterey pines on the burned area. Scattered trees are found almost to the reservoir. Two small groves, 4.1 acres, were placed on the map where this tree forms dense stands. One of these survived the fire of 1931. The trees there are only 10 to 15 feet high, the older ones being about 30 years old. The other area consists of more reticles that have come in since the fire. These tiny trees, often only 12 inches high, but 10 to 15 years old, bear cones in abundance. This type has no value other than the interest taken in the peculiarities of the species.

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Table IV — Areas by Age Classes and Site Quality — Monterey Pine

Age Class or Sub-type	Site Quality	Area in Acres	Totals
1 - 20 yrs.	I	138.5	
1 - 20 yrs.	II - III	895.7	1034.2
21 - 40 yrs.	II	255.4	255.4
41 - 60 yrs.	I - II	1570.8	1570.8
Irregular	I	364.0	
Irregular	II - III	872.5	1236.5
Beach protection Belt	III	158.0	158.0
		Total	4254.9

Table IV — Areas by Age Classes and Site Quality — Monterey Pine

Age Class or Non-type	Site quality	Area in Acres	Totals
1 - 20 yrs.	I	138.3	
1 - 20 yrs.	II - III	385.7	1034.3
21 - 40 yrs.	II	253.4	253.4
41 - 60 yrs.	I - II	1870.3	1870.3
Irregular	I	364.0	
Irregular	II - III	872.5	1236.5
Beach protection Belt	III	158.0	158.0
	Total	4552.9	

majority of the trees in the stand was taken as the basis for division into age classes. In all the age classes many trees above and below the age limits will be found.

Age Class 1 - 20 years: This consists of several small irregular dense patches just south of Pacific Grove, classed as Site I, probably the result of fires or clear cuttings; a considerable area on Carmel Hill, the result of fire; and 844 acres burned over by the fire of 1901 and subsequently clear cut, extending from the northeast boundary fence over Huckleberry Hill to the reservoir. (See map.) The last two areas have been classed as Site II-III, the soil being generally thin and poor except on the north and east slopes. Most of the trees in this class are 15 to 20 years old. The stands are usually very dense and on the poorer sites average 15 to 25 feet in height and rarely reach 6 inches in D.B.H. There is often a very dense undergrowth of Poison Oak and Ceanothus, which sprang up after fires and is now being shaded out. On Site I and II, the trees are often 6 to 8 inches in D.B.H., and 30 to 50 feet high. These stands are all far too dense, there being 7,000 to 8,000 trees per acre in some cases. On poorer sites and in wet places, about 8% of the trees have galls, or swellings, on the main stem, caused by the fungus

Peridermium harknessii, and about 5% are attacked by pine mistletoe, Razoumofskya campylopoda.

The Intermediate Age Class, 21 - 40 years: This is deficient in area from the standpoint of management, there being only 255.4 acres, consisting of several isolated small stands, mostly on good soil. These stands are also too dense. The trees range in size from 3 to 4 inches in D.B.H., and 30 to 50 feet in height, to 12 or 14 inches in D.B.H. and 60 to 80 feet in height, with scattered, larger, older, trees, survivors of cuttings or fires. There is a considerable range in age, but most of the trees are from 25 to 35 years old. These stands being on the better sites are not excessively damaged by the pine gall fungus or mistletoe.

The Mature Age Class, 41 - 60 years: This is the most extensive and important one. The greater part of this timber is located on the belt of good soils on the lower slopes, inside the sand hills and openings of the beach. The best of this will be found from a point about one-half mile from the southern limits of Pacific Grove to the reservoir and westward to the protection belt along the beach. These stands are remarkably uniform. (See photograph, p. 24.) On the better sites the trees are mostly 12 to 24 inches in D.B.H. and 70 to 90 feet in height, but trees 36 inches in diameter and 110 feet high are found. The average age is about 50 years. Stands southwest

Particularly burdensome, and about 3% are attacked by pine
mistletoe. Reconnoitered completed.

The Intermediate Age Class, 21 - 80 years: This is
deficient in area from the standpoint of management, there
being only 352.4 acres, consisting of several isolated small
stands, mostly on good soil. These stands are also too dense.
The trees range in size from 1 to 4 inches in D.B.H., and 30 to
50 feet in height, to 12 or 14 inches in D.B.H. and 60 to 80
feet in height, with scattered, larger, older trees, survivors
of cuttings or fires. There is a considerable range in age,
but most of the trees are from 35 to 75 years old. These
stands being on the better sites are not excessively damaged by
the pine gall fungus or mistletoe.

The Mature Age Class, 81 - 80 years: This is the most
extensive and important one. The greater part of this timber
is located on the belt of good soils on the lower slopes, inside
the sand hills and openings of the ponds. The best of this will
be found from a point about one-half mile from the southern
limits of Pacific Grove to the reservoir and westward to the
protection belt along the beach. These stands are remarkably
uniform. (See photograph, p. 36.) On the better sites the
trees are mostly 12 to 24 inches in D.B.H. and 70 to 80 feet in
height, but trees 36 inches in diameter and 110 feet high are
found. The average age is about 80 years. Stands containing

of the reservoir are somewhat younger.

Few trees over 60 years old occur in this type. These uniform stands are probably the result of extensive cuttings said to have been made during the '60's, when a sawmill was built on Sawmill Creek and all the larger trees removed. The stands are usually somewhat understocked, the denser ones having about 150 trees per acre. The crowns are 15 to 30 feet in length; the stems usually have considerable crook, and the stubs of dead branches persist to within 20 or 30 feet of the ground. Stands in this age class rarely exceed 30,000 feet B.M. per acre, or 55 cords (95 California cords). The average stand is about 10,000 ft. B.M., or 20 cords per acre.

West and southwest of the reservoir the stands are quite open, there being little reproduction and no brush. The litter is very scanty, and owing to this fact and to the thin crowns, grass is often abundant under the trees. Between Sawmill Creek and Pacific Grove there is a considerable understory of Coast Live Oak, or dense reproduction 4 to 10 feet high, and some brush.

Most of the trees in this class have reached their maximum height growth, and the current diameter growth is rapidly declining. There is considerable damage by the heartwood destroying fungus, Trametes pini. The bark of the lower trunk

of the reservoir are somewhat younger.

Few trees over 60 years old occur in this type. These uniform stands are probably the result of extensive cuttings said to have been made during the '80's, when a sawmill was built on Sawmill Creek and all the larger trees removed. The stands are usually somewhat understocked, the donger once having about 150 trees per acre. The crowns are 15 to 30 feet in length; the stems usually have considerable crook, and the ratio of dead branches persist to within 20 or 30 feet of the ground. Stands in this age class rarely exceed 30,000 feet B.M. per acre, or 55 cords (95 Californian cords). The average stand is about 10,000 ft. B.M., or 20 cords per acre.

West end condition of the reservoir the stands are quite open, there being little reproduction and no brush. The latter is very scanty, and owing to this fact and to the thin crowns, there is often abundant under the trees. Between Sawmill Creek and Pacific Grove there is a considerable understory of Coast Live Oak, or dense reproduction 4 to 10 feet high, and some brush.

Most of the trees in this class have reached their maximum height growth, and the current diameter growth is rapidly declining. There is considerable damage by the heartwood decaying fungus, Trametes pini. The bark of the lower trunk

An even-aged mature stand of Monterey Pine. Clearing 100 ft. wide made for a railroad. Note the abundant reproduction.

Drive and cleared roadways through an even-aged mature stand of Monterey Pine.

An even-aged mature stand of Monterey Pine. Crossing 100 ft. wide made for a railroad. Note the abundant reproduction.

Drive and cleared roadway through an even-aged mature stand of Monterey Pine.

(Photo. by D. Bruce)

Even-aged open stand of Monterey Pine below Clay Pits reservoir. Average age, 45 years. Stand per acre, 45 cords (25,000 Bd. ft.).

(Photo. by D. Bruce)

Granite formation near Pt. Cypress. Note the exposed situation of the Monterey Cypress trees in the background.

(Photo. by D. Bruce)

Grevillea formation near Pt. Cypress. Note the exposed situation of the Monterey Cypress trees in the background.

(Photo. by D. Bruce)

Stand per acre, 45 cords (25,000 B. F.).

Clay Pitts reservoir. Average age, 45 years.

Seven-aged open stand of Monterey Pine below

is often cancered by mistletoe which grows from the fissures, and injury from bark beetles often follows.

The Irregular Type: The best of this type will be found adjoining Pacific Grove on the south, where it occupies some of the best soil on the tract. The irregularity in size and age is doubtless due to frequent cordwood operations. There is often a dense understory of reproduction, saplings, and poles, with scattered mature, very large trees. On good soils there is a considerable mixture of Coast Live Oak and brush and heavy ground cover of ferns. On this area Monterey Pine makes the most rapid growth and reaches its largest size, due to the good soil and to old cuttings which have given certain trees unlimited light. In such cases the crowns become very wide and irregular, the branches attaining large size. These trees, where they occur with oak along the drives, are a valuable asset from the aesthetic standpoint. Farther back in the production forest such "wolf trees" occupy too much space. On this site a few trees were found 50 to 54 inches in D.B.H. and 90 to 110 feet high. The older trees are seldom over 75 years old. One tree measured was 46 inches in D.B.H. and 60 years old, the widest annual ring being about 1 inch. (See photograph, p. 27.) The stand per acre is usually less than 30,000 feet B.M., the average being about 8,000 ft. B.M. or 16 cords.

A windfall in the Irregular Type. Note the shallow root-system and absence of a tap-root in the mature Monterey Pine. The trees in the background received too much side light, resulting in large irregular crowns.

Cross-section of Monterey Pine stem showing rapid growth and short life. This tree was 57 yrs. old and 46.6 inches in diameter at the stump (1 ft. high). Although it stood on good soil and had abundant light, the diameter growth had fallen off rapidly. Between the ages of 10 yrs. and 20 yrs., this tree grew 16 inches in diameter at the stump. (Tape graduated in feet, tenths, and hundredths.)

A windfall in the Irregular Type. Note the shallow root-system and absence of a tap-root in the mature Monterey Pine. The trees in the background received too much side light, resulting in large irregular crowns.

Cross-section of Monterey Pine stem showing rapid growth and short life. This tree was 37 yrs. old and 44.6 inches in diameter at the stump (1 ft. high). Although it stood on good soil and had abundant light, the diameter growth had fallen off rapidly. Between the ages of 10 yrs. and 20 yrs., this tree grew 16 inches in diameter at the stump. (Tape graduated in feet, tenths, and hundredths.)

On the southwest slope the trees are much smaller, owing to poor soil. Damage from insects, fungi, and mistletoe is sometimes considerable here. A strip of timber, extending from near the reservoir toward the beach, has been classed as irregular. Here there is often a very dense mixture of saplings and poles. On the north slope of Huckleberry Hill and on Carmel Hill, the areas classed as irregular are on good soil and the trees are of moderate size.

The Beach Protection Belt: This type consists of several narrow strips, 100 to 300 feet wide, where the timber meets the sand hills, or openings along the beach. The trees are usually low and irregular, often merely sprawling along the ground, due to exposure to the wind. This type is not considered for wood production, but is a valuable factor in retaining sand dunes and in protecting the main timber belt from the wind. This belt is slowly advancing inland, as drifting sand and exposure gradually eliminate the older trees, and grazing, adverse winds, and shifting sand prevent seeding back toward the beach.

2. Estimates

a. Present Volume.— In preparation for this plan, an estimate was made of the merchantable timber within the boundaries indicated on the map, including all trees 6 inches and over in D.B.H. The cypress type and the beach protection belt were not estimated. On the extensive

2. Estimates

a. Present Volume.— In preparation for this plan, an estimate was made of the merchantable timber within the boundaries indicated on the map, including all trees 6 inches and over in D.B.H. The cypress type and the beach protection belt were not estimated. On the extensive

Beach Protection Belt. Sand hills near Point Cypress, California. Note the abrupt slope where the sand meets the forest.

The Beach Protection Belt. Monterey Pines exposed to the wind, near Point Cypress, California.

Beach Protection Belt. Sand Hill near Point Cypress, California. Note the shrub slope where the sand meets the forest.

The Beach Protection Belt. Monterey Pines exposed to the wind, near Point Cypress, California.

Point of a sand dune which is moving slowly out into an opening. Near Point Cypress, California.

Shrubs which are important in retaining sand, near Point Cypress, California.

Point of a sand dune which is moving slowly out into
an opening. Near Point Cypress, California.

Shrubs which are important in retaining sand, near
Point Cypress, California.

burned area, the 1 - 20 year age class is seldom of merchantable size. The results are expressed in board feet and cords for comparison, and in short, or California cords, the customary standard in this region. According to a recent state law, a cord must contain 128 cu. ft. (For methods of estimating and computation, see appendix.) A summary is made in Table V, below.

The total volume in board feet of trees 8 inches and over in D.B.H.* amounts to about 28,160,000 bd. ft. Expressed in cords, including all trees over 6 inches in D.B.H., the result is 54,568 cords. The large volume in board feet, in the 1 - 20 year age class, is due partly to the presence of scattered older trees. Sound, standing, dead trees are given as "merchantable dead." The large amount of wind fall is unusual, judging from the number of trees uprooted in previous years, and is due largely to a severe windstorm in January 1916.

b. Growth.— The annual growth was estimated by sample plots, taken in representative stands of each age class and site quality of which a considerable area occurs. The results suffice for present purposes of regulation, but a more intensive growth

*Diameter at breast height — 4½ ft. above ground.

Table V — Present Volume by Age Classes — Monterey Pine

Age Class	1 - 20 yrs.			21-40 yrs.			41-60 yrs.			Irregular			Totals		
Area - Acres	1034.2			255.4			1570.8			1236.5			4096.9		
	1000 Board Feet	Cords	Calif. Cords	1000 Board Feet	Cords	Calif. Cords	1000 B.f.	Cords	Calif. Cords	1000 Board Feet	Cords	Calif. Cords	1000 Board Feet	Cords	Calif. Cords
Merchantable Dead	---	---	---	---	---	---	20.3	37	64	76.8	138	238	97.5	175	302
#Windfall	5.2	9	16	8.9	16	28	18.3	33	57	178.0	320	552	210.5	379	653
Green	774.5	1597	2753	1195.3	2741	4725	16147.4	30945	53353	9735.1	18732	32297	27852.3	54014	93128
Totals	779.7	1606	2769	1204.2	2757	4753	16186.0	31015	53474	9989.9	19190	33087	28160.3	54568	94083
Average stand per acre	0.8	1.56	2.68	4.6	10.79	18.62	10.3	19.74	34.04	8.1	15.51	26.77	6.9	13.32	22.96

#Does not include that in Pacific Grove, Pebble Beach, the beach protection belt, and Cypress type. The total is probably about 200(California cords. (California cord is 2 tiers, 8 ft. long, 4 ft. high, and 14" wide.)

study is desirable. The results are not to be regarded as representing the natural development of the species at various ages, owing to artificial conditions caused by cuttings and fires. All trees 3 inches and over in D.B.H. are included. The results are summarized in Table VI, below. Only the actual producing area is considered, brush areas, natural openings, and clearings for about 38 miles of roadways, having been excluded. The total annual growth is estimated at 3,900 cords (6,700 short cords).

Table VI — Annual Growth by Age Classes — Monterey Pine

				Ann. Growth per acre			Totals		
Age yrs.	Site Quality	Area Acres	Reduced Area*	B.f.	cds.	Cal. cds.	1000 B.f.	cords.	Cal. cds.
1— 20	I	138.5	131.5	332	3.69	6.37	43.6	485	838
1— 20	II-III	895.7	867.7	---	0.39	0.67	----	338	581
21— 40	II	255.4	247.4	135	1.51	2.60	33.4	374	643
41— 60	I-II	1570.8	1470.8	550	1.00	1.72	808.9	1471	2530
Irreg.#	I	364.0	349.0	569	1.25	2.16	198.8	436	754
Irreg.#	II-III	872.5	810.5	556	0.98	1.69	450.6	794	1370
Totals		4096.9	3876.9				1535.3	3898	6716

* Area reduced by approximately 220 acres for cleared roadways.

\# Periodic annual growth for last 10 yrs. All others are mean annual growth.

study is desirable. The results are not to be regarded as repre-
senting the natural development of the species at various ages,
owing to artificial conditions caused by cutting and fires. All
trees 5 inches and over in D.B.H. are included. The results are
summarized in Table VI, below. Only the actual producing area is
considered, brush areas, natural openings, and clearings for about
30 miles of roadway, having been excluded. The total annual
growth is estimated at 3,900 cords (6,700 short cords).

Table VI — Annual Growth by Age Classes -- Monterey Pine

Age Yrs.	Site Quality	Area Acres	Reduced Area*	Ann.Growth per acre B.f.	cds.	Cri.cds.	Total 1000 B.f.	Tot. cords	Cri. cds.
1 — 20	I	138.5	121.5	332	3.69	6.37	41.6	485	838
1 — 20	II-III	895.7	867.7	----	0.29	0.67	----	338	581
21 — 40	II	285.4	247.4	135	1.51	3.60	33.4	374	642
41 — 60	I-II	1570.6	1470.8	350	1.00	1.72	808.9	1471	2530
Irreg.½	I	364.0	340.0	369	1.35	2.16	198.8	456	784
Irreg.½	II-III	871.5	810.5	356	0.98	1.69	450.6	734	1272
Totals		4096.9	3876.9				1533.3	3882	6716

* Area reduced by approximately 220 acres for cleared roadways.

½ Periodic annual growth for last 10 yrs. All others are mean annual growth.

3. Past Operations

a. Cuttings.— The entire tract has been cut over repeatedly in past times. These earlier operations were entirely unregulated. A mill is said to have operated during the '60's, removing most of the larger timber on the west slope. Until recent years, most of the cutting was done by cordwood contractors. In 1903 and 1904, a heavy damage cutting was made necessary by an infestation of bark-beetles after the severe fire of 1901. At this time about 15,000 cords were cut. Thinnings were made in 1904 along the Seventeen-Mile Drive. These thinnings were light (Grade B), in stands 20 to 30 years old the suppressed trees and those attacked by the pine gall fungus and mistletoe being removed, amounting to 3,500 cords. During the last 5 years or more, operations have been in the nature of damage cuttings, removing insect-infested trees and wind falls. Within the last 10 years many miles of roadways, mostly 50 feet in width, have been cleared through the forest. The average cost of clearing and grubbing was about $30 per acre. The wood removed scarcely more than paid for the operation, since it contained much small round material.

b. Present Utilization.— A large part of the windfall of this spring has been sold on a stumpage basis to Japanese contractors, at $1.50

3. Past Operations

a. Cuttings.— The entire tract has been cut over repeatedly in past times. These earlier operations were entirely unregulated. A mill is said to have operated during the '60's, removing most of the larger timber on the west slope. Until recent years, most of the cutting was done by cordwood contractors. In 1902 and 1904, a heavy damage cutting was made necessary by an infestation of bark-beetles after the severe fire of 1902. At this time about 12,000 cords were cut. Thinnings were made in 1904 along the Beaverdam-Mills Drive. These thinnings were light (Grade B), in stands 20 to 30 years old the suppressed trees and those attacked by the pine gall fungus and mistletoe being removed, amounting to 3,500 cords. During the last 3 years or more, operations have been in the nature of damage cuttings, removing insect-infested trees and wind falls. Within the last 10 years many miles of roadway, mostly 30 feet in width, have been cleared through the forest. The average cost of clearing and grubbing was about $30 per acre. The wood removed scarcely more than paid for the operation, since it contained much small round material.

b. Present Utilization.— A large part of the windfall of this spring has been sold on a stumpage basis to Japanese contractors, at $1.50

per California cord, the wood being piled at the stump, usually in 2 tiers, 8 feet 4 inches long, and 4 feet 4 inches high (14 inch sticks), one stake being placed at each end of each tier. (Four inches in length and height is allowed for shrinkage.) Considerable wood, in odd places, is also cut by hired labor at $1.50 per short cord. Isolated dead trees are often sold on a stumpage basis to residents at $1.50 per short cord, the trees being designated by the superintendent. Cones, bark from dead trees, and some pole-wood are sold by the load, collection being made by the gate-keepers. This amounts, in all, to about $600 per year and serves to prevent the development of the free-use custom.

Stumps are cut from 8 to 12 inches from the ground, and the stem is utilized to 2 inches in diameter at the top. Branch wood is hard to sell, and all but the larger branches which can be split are piled and burned. The wood is allowed to season during the summer. If it remains in the woods during the winter and becomes weather-stained, it is difficult to dispose of. Wood cut by the Company's men is hauled in large loads directly to the consumer. Teams of 4 horses hauling 4 short cords to the load are used. For hauls of over 3 miles in length, one man makes one trip a day; for hauls under 3 miles in length, a driver and helper haul 2 loads or more a day, saving about 40% per cord over the longer hauls. The cost is approximately as follows:

per California cord, the wood being piled at the dump, usually in 8 tiers, 8 feet 4 inches long, and 4 feet 4 inches high (14 inch sticks), one stake being placed at each end of each tier. (Four inches in length and height is allowed for shrinkage.) Considerable wood, in odd places, is also cut by hired labor at $1.50 per short cord. Isolated dead trees are often sold on a stumpage basis to residents at $1.50 per short cord, the trees being designated by the superintendent. Cones, bark from dead trees, and some pole-wood are sold by the load, collection being made by the gate-keeper. This amounts, in all, to about $500 per year and serves to prevent the development of the fire-ure center.

Stumps are cut from 6 to 14 inches from the ground, and the stem is utilized to 3 inches in diameter at the top. Branch wood is hard to sell, and all but the larger branches which can be split are piled and burned. The wood is allowed to season during the summer. If it remains in the woods during the winter and becomes weather-stained, it is difficult to dispose of. Wood cut by the Company's men is hauled in large loads directly to the consumer. Teams of 4 horses hauling 4 short cords to the load are used. For hauls of over 3 miles in length, one man makes one trip a day; for hauls under 3 miles in length, a driver and helper haul 2 loads or more a day, saving about 40% per cord over the longer hauls. The cost is approximately as follows:

Team and driver per day	$ 6.00
Cost cutting and piling 4 cds., at 1.75	7.00
4	13.00
Total cost per Calif. cd., one trip a day	$ 3.50

or

Team and driver per day	$ 6.00
helper per day	1.50
Cost cutting and piling 8 cds., at 1.75	14.00
8	21.50
Total cost per cd., 2 trips a day	$ 2.69

The cost varies considerably, depending on the exact location of the wood and the difficulty of getting it to a good roadway. Wood to the east of the summit of Huckleberry Hill usually goes directly to Monterey over the county road. By far the greater part is brought out by way of Pacific Grove. The average selling price is $6.00 per short cord delivered, leaving a profit of $2.50, or more, per cord.

A considerable amount of wood 4 feet in length is used by the Company's hotels in open fires, but oil is used for cooking and steam-heating. During the last several years, a total of from 1,000 to 1,200 California cords have been cut annually.

A small circular mill, run by electricity, is situated near Pebble Beach. A small amount of lumber is cut for use on the place. Logs are sometimes slabbed off on two sides for the construction of rustic houses.

Team and driver per day $ 6.00

Cost cutting and piling 4 cds., at 1.75 7.00

4 $13.00

Total cost per Calif. cd., one trip a day $ 3.50

or

Team and driver per day $ 6.00

helper per day 1.50

Cost cutting and piling 8 cds., at 1.75 14.00

8 $21.50

Total cost per cd., 2 trips a day $ 2.69

The cost varies considerably, depending on the exact location of the wood and the difficulty of getting it to a good roadway. Wood to the east of the summit of Huckleberry Hill usually goes directly to Monterey over the county road. By far the greater part is brought out by way of Pacific Grove. The average selling price is $6.00 per chord cord delivered, leaving a profit of $2.50, or more, per cord.

A considerable amount of wood 4 feet in length is used by the Company's hotels in open fires, but oil is used for cooking and steaming. During the last several years, a total of from 1,000 to 1,500 California cords have been cut annually.

A small circular mill, run by electricity, is situated near Pebble Beach. A small amount of lumber is cut for use on the place. Logs are sometimes slabbed off on two sides for the construction of rustic houses.

The total income from the forest itself is difficult to estimate. The income from toll-roads is largely due to the presence of the forest. The exact value of grazing is not known. There is a considerable income from the rental of openings along the beach to the War Department for drill grounds. It will be seen that taxes cannot fairly be charged entirely against the forest. This is true also of the expense of superintendence, which is distributed between the forest, the roads, the sand industry, etc. The expenses of two year-long patrolmen is chargeable to the forest.

c. Protection.— Two riding patrolmen are employed the year round. One of these patrols the southern half of the tract, with headquarters near the Carmel boundary above the pipe line; the second patrols the northern half, with headquarters at the reservoir. The superintendent's residence, the patrolmens' headquarters, and a construction camp at Pebble Beach are connected by telephone lines. When weather conditions cause danger from fire, these men spend most of their time on patrol along routes frequented by tourists. At other seasons, part of their time is spent in burning brush, cutting out trails, killing predaceous animals, and preventing hunting.

Important work in insect control was done in 1903 and 1904 under the direction of G. A. Coleman, when 15,000 cords of infested

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Stumps and wood after working up windfalls. Monterey Pine near Pacific Grove.

Mature stand of Monterey Pine with scattered oaks and reproduction, near Pacific Grove.

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Mature stand of Monterey Pine with scattered oaks and reproduction, near Pacific Grove.

timber was cut. About 1200 trees and stumps were treated for bark-beetles, at a cost of 10 cents each. The sale of wood more than paid for the cost of the campaign. Subsequent losses from insects were undoubtedly greatly reduced. Since then, men have been employed from time to time to treat scattered infested trees.

d. Administration.— The forest is administered by the Company's superintendent. Two special patrolmen and game wardens are employed, as stated above, and a foreman has been in charge of Japanese wood cutters. Otherwise, the Company's regular employees are assigned to forestry work as needed.

PART III

MANAGEMENT OF THE FOREST

---

1. Object of Management

As a source of income, forest products are of secondary importance. The principal value of the tract arises from its aesthetic properties, the driveways, the sand industry, the sale of small plots, etc., but the maintenance of a forest cover is essential. The land is, for the most part, unsuited for agriculture.

The object of management, therefore, is, first, to maintain the forest in the best possible condition, from the standpoint of appearances, especially in the immediate vicinity of drives and residence sections; and, second, to derive a profit from cord-wood and minor products.

2. Administration

The present method of administration should be continued. At present the income will not justify the employment of a technical forester. From time to time a consulting forester should be engaged to mark sample plots for thinnings and cuttings, and to recommend insect or other control measures.

3. Division of the Area

For the present, division of the area is necessary only to simplify explanation and the keeping of records. Eight compartments

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have been made, as indicated on the accompanying map, based on accessibility and condition of the forest. The boundaries are roads or topographic features where possible. Each compartment has been designated by a number. (See map.) As more intensive methods become possible, the compartments should be made permanent units for operation, and the boundaries changed, somewhat, to correspond more closely to topographic units, or for greater convenience in practice. Further subdivision into sub-compartments will also become necessary. For the present, treatment will be by types, age classes, and site qualities.

4. Treatment by Types

a. The Monterey Pine.— This is the only type of commercial importance. The age classes are considered in order.

Age Class 1 - 20 years: Any cutting operations made in this class during the next ten years should consist of thinnings to improve growth, and damage cuttings to remove trees attacked by the pine gall fungus and mistletoe. Owing to the difficulty of disposing of thinnings, unless favorably located, no present income can be expected from such cuttings. At first, therefore, operations should be confined to places where improved appearances justify the expenditure, as along the drives.

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Thinnings are very desirable, because the intermediate age class is deficient in area, and to sustain the yield, mature timber must be held over until this young timber attains merchantable size.

In case thinnings are undertaken, the beginning should be made on the best sites. The stands to be treated should be selected by a trained forester. Sample plots should be marked and thinned under his direction for the guidance of the superintendent and to instruct the rangers, who should mark areas to be thinned, thereafter.

Stands less than 15 years old should not be thinned. On good soil a heavy (Grade C) thinning should be made, since it will usually be impossible to make a second thinning. The aim should be to leave about 320 properly selected trees per acre, an average spacing of about 12 feet each way. All trees with galls or mistletoe on the main stem should be removed, and so far as possible, those also with infested branches. All brush and material which cannot be disposed of should be piled and burned in such a way as not to injure remaining trees.

The first thinnings, when made, should be in the 20-year stands on the good soil between Pacific Grove and Sawmill Creek (see map); next, in the 15-year stands on the northeast slopes of Huckleberry Hill, and on good soil on the northeast slopes of the hill northeast of the Carmel Hill gate. This would amount in all to about 100 acres. No data is available upon which to base an estimate of costs.

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Age Class 21-40 years: The stands placed in this age class are all too densely stocked, and although on good or average sites, growth is retarded. A heavy thinning is required, removing 60 to 70 per cent of the trees. The procedure should be much the same as described above. No rules can be laid down, as much depends on the conditions existing in the individual stand. Marking should be done by the rangers, after instruction, as above. The stand at the reservoir and the ones east of the ridge at Pt. Douty might be selected to begin with. It is believed that sufficient wood may be obtained to pay the cost of thinning. The first thinnings undertaken should be in this age class, first, because there is a possibility of some revenue, and, second, if the trees are left suppressed for much more than 30 years, it is believed they will not respond well to thinnings, except on the best sites. Most of the trees are from 21 to 35 years old. No thinnings should be attempted unless there is a reasonable chance of some present income from the product.

Age Class 41-60 years: Cutting for wood during the next 10 years should be confined to this and the irregular age class.

Cutting in this type, in the region of the Forest Lodge Gate and along the drives, should consist only in the removal of over-mature and diseased trees. Thrifty larger trees should be preserved. Oaks, and reproduction in these places, should be protected. It is

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It is hoped that in time this will result in a more attractive all aged forest. The trees to be removed should be marked by a well instructed ranger.

Between Sawmill Creek and Pacific Grove, stands of this age are mostly mature, 50 to 60 years old, and growth is falling off. These trees occupy good soil, and reproduction is usually excellent. These stands should be clear cut to release the young growth beneath, except along the drives as stated above. Cutting should begin on the east, or leeward, side and progress toward the wind. In this way serious wind fall will be prevented and places where there is no advance growth will be seeded down as cutting proceeds. It will be found necessary in places to cut the oaks also, where these trees have prevented a good stand of reproduction. The rate of cutting will depend on market conditions and cuttings elsewhere.

Stands of this type below the pipe line, between Sawmill Creek and Pt. Cypress, are younger and in fair condition. In these places, for the next few years, cutting should be confined to the removal of dying or diseased trees.

Above the pipe line, on the west and south where the soil is generally rather poor, this type becomes more irregular, the trees are smaller, and the percentage of diseased trees is higher.

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It is hoped that in time this will result in a more attractive all aged forest. The trees to be removed should be marked by a well instructed ranger.

These stands should not be clear-cut, as brush is apt to come in. The aim should be to convert this into a selection forest by the removal of individuals and groups of the larger trees and all dead or inferior trees. It is believed that this will not result in excessive wind fall, since the trees here are more accustomed to exposure. In the stands adjacent to the Pebble Beach subdivision, where the soil varies and the topography is somewhat irregular, the treatment should be similar.

The Irregular Type: Along the drives, this is the most attractive type, and here cutting should be designed, according to the practice in recent years, to improve its appearance. Large healthy pines and oaks should be preserved. Elsewhere, especially on good soils, much heavier cuttings may be made. These should follow the principles of the selection system. Very large trees of irregular form should be removed. Oaks will often be found a hindrance to reproduction, and in such cases should be cut. Groups of saplings and poles will sometimes be found in this type where thinning is desirable. It may be found possible to do part of this thinning in connection with the removal of cordwood. On poorer sites, cutting will be relatively lighter. In general in this type, the age classes are not well distributed. The most desirable percentage of the volume or crown cover to be removed must be determined on the ground.

The Beach Protection Belt: No cutting should be done in this type, except to remove dead and diseased trees or to encourage reproduction. This is intended to prevent wind injury in adjoining stands and to prevent the movement of sand.

b. The Monterey Cypress.— No cutting should be done in this type, except to improve its appearance, as has been the practice in recent years.

c. The Gowan Cypress.— A fire break has already been constructed around the mature stand. This is all that is justified by its value as an object of interest.

d. The Bishop Pine.— Very little can be done in this type during the next decade, due to the conditions existing there. This species is an inferior one, and the ultimate object should be to replace it with Monterey Pine. When it occurs in mixture in young stands being thinned or improved, it should be removed.

e. Brush Areas.— Brush areas are usually the result of fires and early unrestricted cuttings on poor sites. In many places dense brush will be found under timber, which is not indicated on the map. Most of the pure chaparral areas are "natural," i.e. on very poor sites, such as rocky points or very steep slopes, unsuited for tree growth. On favorable sites, the ground is usually reclaimed by pine.

The Beach Protection Belt: No cutting should be done in this type, except to remove dead and diseased trees or to encourage reproduction. This is intended to prevent wind injury in adjoining stands and to prevent the movement of sand.

5. The Monterey Cypress.— No cutting will be done in this type, except to improve its appearance, as has been the practice in recent years.

6. The Brown Cypress.— A fire break has already been constructed around the mature stand. This is all that is justified by its value as an object of interest.

7. The Bishop Pine.— Very little can be done in this type during the next decade, due to the considerable salvaging there. This species is an inferior one, and the ultimate object should be to replace it with Monterey Pine. When it occurs in mixture in young stands being thinned or improved, it should be removed.

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During the next few years, no attempt should be made to reclaim chaparral areas. Ultimately, the aim should be to reforest land on which tree growth can be sustained with certainty. (For shrubs composing chaparral areas, see appendix, p. 74.)

5. Rotation and Yield

It is believed that a rotation of from 50 to 60 years, depending on site quality, will be best for cord-wood production. It is evident from many existing stands that trees of large size, for the species, can be produced in 50 years. Growth studies indicate that the current annual growth falls off rapidly, even on good sites, after 60 years. No data is available to determine the yield which may be expected from Monterey Pine in a regulated forest. It is believed, however, that present yields can be considerably increased.

6. Regulation of the Yield

Considering the tract as a unit, the object should be a sustained annual yield rather than periodic heavy cuttings.

During the first 20 years of the rotation, the total annual growth of 3,900 cords should not be cut, since the intermediate age classes in the even-aged type, and in much of the irregular type, are not well represented.

During the next 10 years, 2,500 cords may be safely cut annually. Efforts should be made to build up the market and increase

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the annual cut, which is now less than 700 cords (1200 California cords), to this amount. (At present the Company's superintendent estimates that the local market would absorb an average of about 1500 cords per year — 2000 to 3000 short cords.)

7. Cutting Policy

During the next 10 years cutting should proceed as stated for various types, as follows:

a. Monterey Pine Type.—

1. Age Class 1-20 years: No cutting, except thinnings to improve appearances along drives, or in rare cases on good soil, to improve growth, where there is assurance of some financial gain.

2. Age Class 21-40 years: Thinnings to improve growth only where there is assurance of financial gain from sale of the products.

3. Age Class 41-60 years: Clear cuttings for wood in older stands on good soil; selection cuttings on poor sites. Improvement selection cuttings for aesthetic purposes along drives.

4. Irregular Age Class: Selection cuttings for wood, heavier on good soil than on poor soil; improvement selection cuttings for aesthetic purposes as required.

5. The Beach Protection Belt: No cutting except to remove wind-thrown or dead trees.

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b. In Other Types.— No cutting except to maintain appearances.

Marking: All trees to be removed in selection cuttings or thinnings should be marked, or blazed. This can be done by rangers under the superintendent's supervision, after instruction as described above. The boundaries of areas to be cut clear should be distinctly marked.

Brush Disposal: Brush from wood operations should be piled and burned as a fire protection measure, to improve the appearance of the forest, and, in some cases, to prepare the seed bed for reproduction. Piling should be done at the time of cutting. The piles should be small enough and far enough away from remaining trees to prevent injury during burning. Where possible, the brush should be piled and burned on the recently cut larger stumps. This will prevent infestation of stumps by bark beetles. Burning should be done as at present, by the rangers when the fire danger is least. When wood is sold on a stumpage basis to contractors, proper piling of brush should be insisted upon and insured by frequent inspection, to save unnecessary rehandling by patrolmen.

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8. Planting

No planting should be undertaken under present conditions, for the following reasons: (1) openings available for planting along the beach are producing a larger income in rentals from the War Department and for grazing purposes than could be expected from a forest crop; (2) extensive openings in the Pebble Beach subdivision will probably be used for golf-links, and the status of the land is too uncertain to justify a forest plantation; (3) forestation of brush areas, or attempts to reclaim sand hills, would be very expensive and doubtful of success; (4) successful plantations of considerable size would involve the purchase of nursery stock, or the establishment of a small nursery, as success with wild seedlings is very uncertain. The ultimate aim should be to reforest small natural openings scattered through the forest, after experiments and experience have determined the best methods.

9. Protection

a. Fire.— The present system of patrol should be maintained. During short periods of extreme fire danger, a motorcycle patrolman to follow the drives might be employed to advantage. During the fire season, fire-fighting tools should be kept in convenient places, and the location of men available for fighting fires should be known.

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The fence row between the forest and Pacific Grove should be kept open.

It is recommended that a fence row, or fire-line, be

cleared along the eastern boundary beginning at the southwest Presidio corner, running thence to the northeast corner of the tract, and from there southwest along the boundary line to the county road. This would amount to approximately 2.4 miles of line, and if 25 feet in width, to about 7.3 acres. Until such a clearing can be made, a trail should be chopped out for patrolmen.

The old wood road, extending from the patrolman's headquarters at the reservoir to the opening near the southwest corner of Del Monte Park, and thence across the burn of 1901 to the drive on Huckleberry Hill, should be kept open for passage on horseback. Other trails may be cut out by the rangers from time to time during the winter months to facilitate patrol. Fire warnings and trespass notices should be kept in good condition.

It will rarely be found necessary to restrict grazing, since Monterey Pine reproduces abundantly under most conditions. On certain areas clear cut to be reproduced by seeding from the side, excessive grazing during the wet season, when the ground is soft and forage scarce, would be undesirable.

b. Insects.— Monterey Pine serves as host for a large number of insects, several of which are at times very injurious.

By far the most important insect attacking living trees is the Red Turpentine-beetle (Dendroctonus valens Lec.) The

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adults are dark reddish brown beetles, the females being slightly over one-fourth of an inch in length, the males smaller. The adult beetles and larvae live beneath the bark, feeding on the inner bark and cambium layer of the lower part of the trunk. The presence of the beetles is indicated by granular pitch exudations. When the tree is small, or is attacked by several broods of grubs, it is often completely girdled and dies.

The trees attacked are in most cases those weakened by attacks of fungi and mistletoe, and especially by fire, but many valuable trees in good condition about residences and hotel grounds are attacked.

Control: At the present time attacks of this beetle are confined to scattered trees of the older age classes, throughout the forest, and to valuable landscape trees about Pebble Beach, Del Monte, and other residence sections. It is believed that this insect could be completely exterminated by a well planned campaign, provided cooperation could be secured from neighboring forests. An experienced field entomologist should select and mark the trees for treatment.

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The larval stages are found in the bark throughout the year, but are most abundant during April and May. Trees in the forest which are past hope of recovery should be cut about this time, or earlier, and the bark peeled from the lower trunk and stump. The bark and material which cannot be saved for wood should be burned on the stump, as many of the beetles are in the stump, or enter it after cutting. During cord-wood operations, treatment of the stumps should be the same as stated above.

Spasmodic attempts at control by individuals working alone will have little effect, and should be confined to treatment of valuable trees about parks and grounds. For further description of insect enemies and control, see appendix.

c. Fungus Diseases.— The most serious damage to young timber is caused by the pine gall fungus (Peridermium harknesii). The parasite attacks the branches and main stem, causing globular swellings which vary greatly in size, growing larger with age. When the stem is attacked, the tree usually dies at an early age, or the parts lying beyond the gall die and secondary branches grow up to take their places, the result being a stunted bushy tree of no value. The weakened trees are rendered more susceptible to insect enemies. The few trees with swellings on the main trunk which reach large size are often broken off by the wind at the point of attack.

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The percentage of saplings and seedlings attacked varies with site conditions, being lowest on good soils and highest in very wet places and on poor soil of southwest exposures. In the young timber of the great burned area, from 10% to 20% of the trees have galls on the stem or branches, and the percentage is often much higher. On some areas, as in the wet place near the northwest corner of Del Monte Park, practically all the trees may be rendered worthless.

The control of this disease is a very difficult problem. The orange colored spores, which appear in great numbers from ruptures in the bark of the galls during the spring, are blown everywhere through the forest by the wind. The complete life history of this fungus is not known.

Owing to the great extent of the infection, control measures, for the present, must be confined largely to areas being thinned, as described above. During selection cuttings for cord-wood, it may be possible to cut many infested trees, and during brush disposal, to cut and burn diseased seedlings. Around gardens and grounds, small trees with galls on the main stem should be cut. Limbs bearing galls, or more valuable trees, should be pruned off.

The percentage of saplings and seedlings attacked varies with site conditions, being lowest on good soils and highest in very wet places and on poor soil of southwest exposures. In the young timber of the first burned area, from 10% to 30% of the trees have galls on the stem or branches, and the percentage is often much higher. On some areas, as in the wet place near the northwest corner of Del Monte Park, practically all the trees may be rendered worthless.

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Monterey Pine. Young trees stunted and killed by the pine gall fungus (Peridermium harknessii). The disease causes swellings on the stem and branches, either killing the tree or rendering it worthless by causing excessive branching.

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Other Fungi: The ring scale fungus (Trametes pini) destroys the heartwood of living mature pines. A large number of trees in the vicinity of the Forest Lodge Gate are infected. The presence of the fungus in advanced stages is indicated by the spore-bearing or fruiting bodies, which usually appear on the lower trunk from cavities left by falling limbs. These are hoof-shaped or irregular, the upper side being dark colored and rough, the lower side brownish in color with irregular pores or holes. When the tree is cut, the heartwood is often found to be unsound, the softer or spring-wood part of the annual rings being completely destroyed.

Since only the non-living heartwood is attacked, the trees do not often die, but the most valuable wood is destroyed. During cutting operations, trees with fruiting-bodies of this fungus should always be cut. Destruction of the fruiting-bodies has no effect on the development of the wood destroying mesh-work, or mycelium, of the plant within the tree.

Dead, middle-aged, or mature pines are frequently found which have been killed by the fungus Polyporus schweinitzii. The fruiting-bodies are rather large, shelf-like, and brownish in color, with a porous undersurface. They appear on the trunk near the ground. This fungus continues to rot the wood after the tree is dead. Where possible, trees killed by it should be burned.

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d. The Pine Mistletoe (Razoumofskya (Arceuthobium) campylopoda).— This parasite occurs extensively throughout the forest and causes serious damage. The branches and trunks of small trees are attacked, resulting in stunted, poorly formed trees. Even the older trees will often be found with this plant growing from the bark fissures of the main trunk. The resulting cancered condition of the bark often attracts destructive insects. Under present conditions, this parasite cannot be completely exterminated. Young trees with this parasite on the main stem should be cut wherever possible.

10. Grazing

The tract forms valuable grazing grounds for cattle, brought here for a part of the year from the Company's ranches. The number is said to be usually from 200 to 400 head. All openings indicated on the map are covered with grass. Due to the open crown cover in older Monterey Pine stands and to fires, the layer of litter is usually very scanty, so that over a large part of the area grass is also abundant beneath the trees. Except during a few months in summer, water is plentiful in gulches, and several troughs have been placed along the pipe line of the Monterey County Water Works. Under the present methods, the value derived from grazing far exceeds any damage which results to reproduction.

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The trees form valuable grazing grounds for cattle, brought here for a part of the year from the Company's ranches. The number is said to be usually from 300 to 400 head. All openings indicated on the map are covered with grass. Due to the open crown cover in older Monterey pine stands and to fires, the layer of litter is usually very scanty, so that over a large part of the area grass is also abundant beneath the trees. Except during a few months in summer, water is plentiful in Gulches, and several troughs have been placed along the pipe line of the Monterey County Water Works. Under the present methods, the value derived from grazing far exceeds any damage which results to reproduction.

11. Game

The presence of game adds considerably to the aesthetic value of the forest. Deer are abundant on the tract, and a herd of seven elk have been successfully established. Ample protection is afforded, at present, by prohibiting hunting and destroying predaceous animals.

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The presence of game adds considerably to the aesthetic value of the forest. Deer are abundant on the trail, and a herd of seven elk have been successfully established. Ample protection is afforded, at present, by prohibiting hunting and destroying predacious animals.

APPENDIX

1. Methods of Collecting Data

Estimate.— In estimating the timber, the plot system was used. Using the boundary fences on the north and east as base lines, strips were laid off on the Company's map at intervals of 1650 feet, running S55°W. Lines were run with the Forest Service Standard Compass and distances obtained by pacing. Along these lines at intervals of 5 chains, ⅕-acre circular plots were taken, on which all the trees 6 inches and over in D.B.H. were tallied by 2-inch D.B.H.-classes and 10-foot total height-classes. Diameters and heights were determined by means of a Forest Service cruiser stick, until the estimator's eye became accustomed to the timber. Thereafter the stick was used only at intervals to check the estimator's judgment. A new tally-sheet was begun whenever a decided change in type or age class was encountered. At each circle, notes were taken covering the following points: (1) percentage of the area covered by seedlings, and age and height of same; (2) number of trees below 6 inches in D.B.H., with average height and apparent age; (3) amount of grass; (4) amount of brush; (5) general notes on soil, rock, treatment and condition of timber. Brush areas, openings, and changes in type or age class were sketched on the map. On the north half of the tract intermediate lines were run to improve the map. The actual area of the circular plots estimated composed about 4 per cent of the total area, this being all that

APPENDIX

I. Methods of Collecting Data

Methods.--- In estimating the timber, the plot system was used. Using the boundary lances on the north and east as base lines, strips were laid off on the Company's map at intervals of 1850 feet, running S25°W. Lines were run with the Forest Service Standard Compass and distances obtained by pacing. Along these lines at intervals of 5 chains, ¼-acre circular plots were taken, on which all the trees 6 inches and over in D.B.H. were tallied by 2-inch D.B.H.-classes and 10-foot total height-classes. Diameters and heights were determined by means of a Forest Service cruiser stick, until the estimator's eye became accustomed to the timber. Thereafter the stick was used only at intervals to check the estimator's judgment. A new tally-sheet was begun whenever a decided change in type or age class was encountered. At each circle, notes were taken covering the following points: (1) percentage of the area covered by woodings, and age and height of same; (2) number of trees below 6 inches in D.B.H., with average height and apparent age; (3) amount of trees; (4) amount of brush; (5) general notes on soil, rock, treatment and condition of timber. Brush areas, openings, and changes in type or age class were sketched on the map. On the north half of the tract intermediate lines were run to improve the map. The actual area of the circular plots estimated composed about 4 per cent of the total area, this being all that

limited time and the value of the timber would justify. It is believed that this will give a fair estimate, since the area is large, conditions are uniform, and strips were run at right angles to ridges and streams. A much greater portion of the area was covered for the type map. Forest types often grade into each other, and boundary lines are more or less arbitrary. No attempt was made to secure greater accuracy in the map than its use would justify. The estimate and type map were made without assistance. Corrections should be made in the field where errors are discovered.

Computation.— No volume tables exist for Monterey Pine, and the time was too limited to construct one. In computing the estimate, a volume table for second growth Western Yellow Pine was used, prepared by W. H. Gallaher on the Tahoe National Forest. It was extended graphically. For the larger trees, the Forest Service volume table for Western Yellow Pine in District 5 was used. The values given by these tables were checked by stem measurements of 34 Monterey Pines, and volumes corresponding as given by the Scribner's Decimal "C" log rule, upon which the above tables are based. The values, as given, were found to be approximately 15 per cent too high for Monterey Pine, and this correction was applied to the estimate.

As these tables give volumes in board feet, it was necessary to use a converting factor to express the result in cords. To obtain

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As these tables give volumes in board feet, it was necessary to use a converting factor to express the result in cords. To obtain

this, the diameters and heights of 36 windfallen trees were secured, and the actual amount of wood cut from them was scaled. The board-foot contents was taken from the volume tables, and the ratio of cords per 1000 bd.ft. was computed. The weighted average was found to be 1.8 cords per 1000 bd.ft., or 550 bd.ft. per cord. The California cord consists of 2 tiers of 14-inch wood, 4 feet high, and 8 feet long, and was taken as 0.58 of an ordinary cord. For trees less than 8 inches in D.B.H., which have no board-foot contents, the volumes were obtained from a cubic foot volume table for Lodgepole Pine, given in Forest Service Bulletin No. 234, by D. T. Mason. The next lower D.B.H. class was taken in the table, to allow for difference in bark thickness between Lodgepole and Monterey Pines. Conversion of cubic feet to cords was made on the basis of 75 cu.ft. of actual wood per cord, the value given in "Forest Mensuration," by Henry S. Graves, for sticks of corresponding dimensions.

Sample plots for growth studies were laid out with a compass and tape. The area varied from 33 feet square, in dense saplings, to half an acre in older stands. Diameters were measured with calipers and diameter tape; heights were obtained with an Abney hand level and clinometer; ages and diameter growth were taken from increment borings, or by cutting smaller trees. Stem analyses were taken for 9 trees cut for wood, and taper measurements were made on 24 additional windfalls. The age required by seedlings to reach stump height was obtained by measurements of 35 cut seedlings.

this, the diameters and heights of 36 windfallen trees were measured, and the actual amount of wood cut from them was scaled. The board-foot contents was taken from the volume tables, and the ratio of cords per 1000 bd.ft. was computed. The weighted average was found to be 1.8 cords per 1000 bd.ft., or 550 bd.ft. per cord. The California cord consists of 2 tiers of 14-inch wood, 4 feet high, and 8 feet long, and was taken as 0.90 of an ordinary cord. For trees less than 8 inches in D.B.H., which have no board-foot contents, the volumes were obtained from a cubic foot volume table for lodgepole Pine, given in Forest Service Bulletin No. 234, by D. T. Mason. The next lower D.B.H. class was taken in the table, to allow for difference in bark thickness between Lodgepole and Monterey Pines. Conversion of cubic feet to cords was made on the basis of 75 cu.ft. of actual wood per cord, the value given in "Forest Mensuration," by Henry S. Graves, for sticks of corresponding dimensions.

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Areas of types indicated on the map were obtained with a planimeter. Careful measurement of plots of known area and lines of known length indicated that the map had shrunken approximately one per cent from exposure in the field. This correction was therefore applied to all computations of area.

2. Investigations

The administration of a forest according to principles of forest management presupposes careful preservation, in usable form, of all data concerning operations in the forest. Under intensive management, blank forms and a filing system must be devised for the keeping of complete records of each compartment and stand. This can best be done by the administration, as practice dictates.

The need of further growth studies has already been mentioned.

A cordwood volume table for Monterey Pine under local conditions would be of great value in making stumpage sales or future estimates. The data needed consist of D.B.H. and total height measurements of as many trees as possible in each diameter class, together with the actual amount of wood cut from the trees under local methods.

In connection with cutting operations and fire protection, additional weather data within the forest would be of great value.

Arrangements could probably be made whereby records of temperature, wind direction, severe storms, number of foggy days, etc., could be secured in connection with the present rainfall records, with but slight additional expense. Complete fire records, covering origin, location, area burned, date, etc., are very desirable.

3. The Monterey Cypress

The Monterey Cypress (Cupressus macrocarpa Hartw.) occurs naturally only in the small groves found on Point Cypress and Point Lobos. Trees near the ocean, due to exposure to the wind, are often fantastically gnarled and twisted, with many dead branches and ashy grey trunks. The appearance of these trees has doubtless led to the belief that they are of very great age.

During the recent storm of January 1916, many trees, including several of the larger ones, were blown down. These were subsequently cut into cordwood, giving an opportunity to count the annual rings at stump height, and thus determine the age. It is, in some cases, difficult to distinguish individual rings, and the time required by the tree to reach stump height (usually one or two feet) is, of course, unknown; but, the error from these sources can in no case amount to more than five or ten years. Ring counts on stumps were supplemented by ring counts on cores of wood obtained by boring into standing trees with an increment borer.

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In all, stump counts, or borings, were taken from fifteen trees of different sizes, including the largest which could be found. A tree, considered to be a fair representative of the older mature trees, was 62 inches in diameter, inside the bark at 4 feet above ground, and had at this point 225 annual rings. The accompanying diameter growth curve was constructed by counting the rings into decades and measuring the radial distance from the center to each decade, the results being plotted, as shown. From the curve, the diameter of the tree at this height for any age may be obtained by reading the corresponding radius and multiplying by two.

The largest standing tree which could be found had an average diameter of approximately 72 inches, at 4½ feet from the ground. During the last 120 years this tree had grown, on an average, 1.32 inches in diameter per decade. Assuming that this tree never grew more rapidly, even in youth, which is unlikely, the age would not be more than 550 years. Diameter growth curves, which make allowance for accelerated growth during youth, indicate that this tree was probably not more than 350 years old.

Other representative larger trees were found to be as follows:

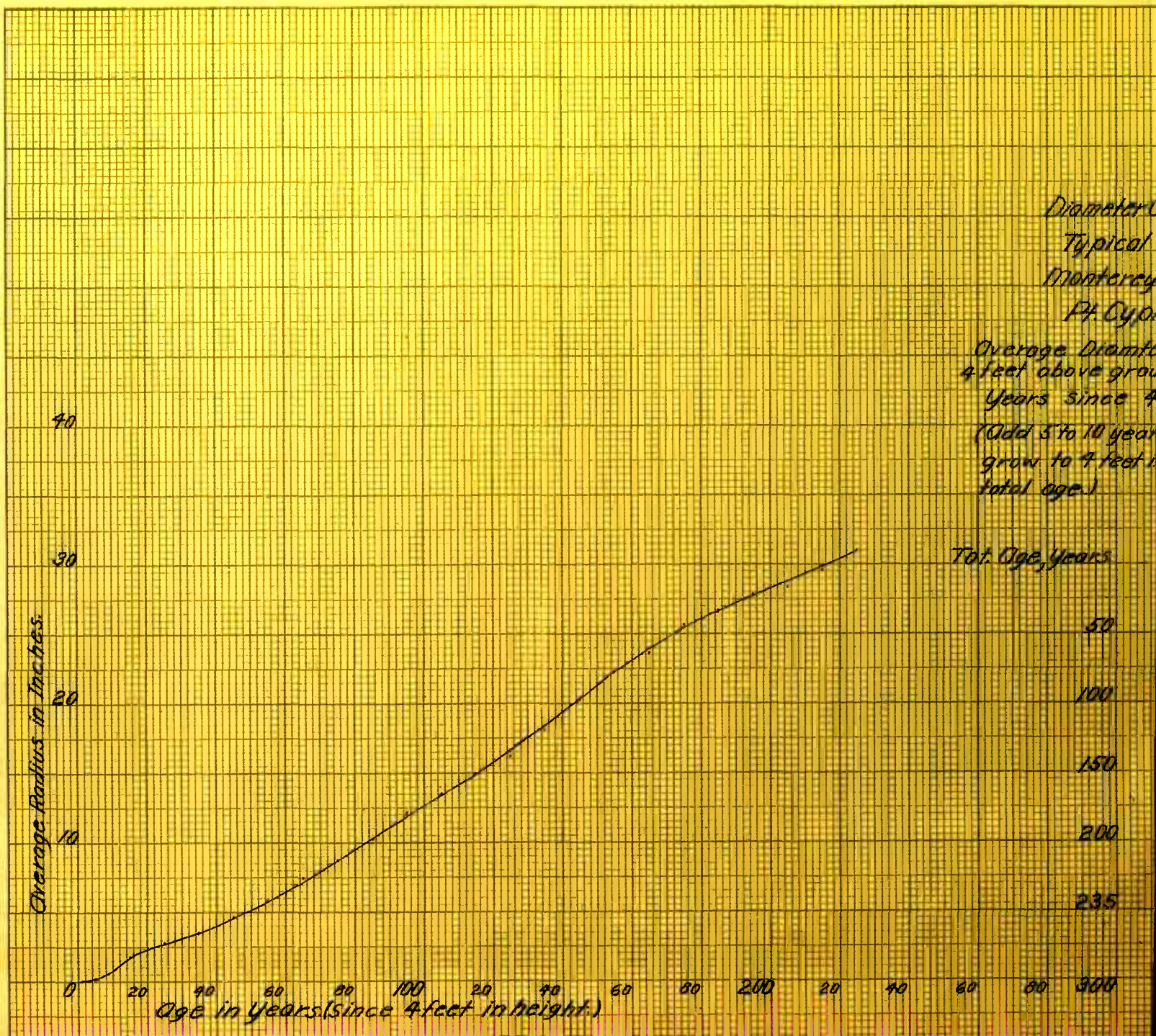
Tree No.1 — Diameter (4½ ft. above ground) 13 inches; age 95 years.

Tree No.2 — Diameter (4½ ft. above ground) 15 inches; age 60 years.

Tree No.3 — Diameter (1 1/3 ft. above ground) 30 inches; age 103 years.

Tree No.4 — Diameter (2 ft. above ground) 26 inches; age 101 years.

Diam. inside bark
Inches.
13.0
23.2
46.4
53.8
62.0


Diameter
Typical
Monterey
Pt. Cy.
Average Diamet
4 feet above grou
Years since 4
(Add 5 to 10 year
grow to 4 feet
total age.)
Tot. Age, Years
50
100
150
200
235
40
30
20
10
0
Average Radius in Inches.
20
40
60
80
100
20
40
60
80
200
20
40
60
80
300
Age in Years (Since 4 feet in height.)

It may be said with certainty that the greater number of trees are less than 250 years old, and that the Monterey Cypress seldom, if ever, attains a greater age than 400 years.

For further description of Monterey Cypress consult:

"A Silva of California" by Willis L. Jepson.

"Forest Trees of the Pacific Slope" by G. B. Sudworth.

4. Additional Notes on Bishop Pine (Pinus muricata Don)

Bishop Pine may be readily distinguished from Monterey Pine by the lighter green and coarser foliage. The leaves occur in fascicles of 2, instead of in 3's as in Monterey Pine, and are longer, being 4 to 6 inches in length. The cones are smaller than those of the Monterey Pine, being 2 to 3 inches long, the scales bearing prominent persistent prickles. This species will be replaced, at length, by Monterey Pine, if fires are prevented. It bears cones in abundance after 10 years of age; as many as 4 whorls of cones, each with from 3 to 8 cones, are sometimes borne in a single season by trees 15 years old on this burned area. A tree near the Presidio corner, on the eastern part of this area, was 15 feet high, 1 inch in D.B.H., and 15 years old; it bore 12 whorls of cones, the first appearing 3 feet from the ground. The cones, however, remain closed for many years (10 years or more) unless opened by fire, and while the quality of the seed is high, the Monterey Pine, the cones of which usually open in the third or fourth year, is thus given a decided advantage, except in case of fires.

The Monterey Cypress.
(Cupressus macrocarpa Hartw.)

Exposure to the wind has given these trees the appearance of great age.

The Monterey Cypress.
(Cupressus macrocarpa Hartw.)

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5. Additional Notes on Monterey Pine

Seed Bearing.— Monterey Pine is a prolific annual seeder. The statement has often been made that the cones remain closed for many years. This is now believed to be incorrect. The cones mature in the autumn of the second season, and usually open during the first warm days early in the following spring. Thereafter, old cones open and close repeatedly, whenever changes in the temperature and moisture of the air are sufficiently great. In the region where the tree grows, the air is usually cool and moist, and consequently the cones remain closed most of the time. The cones remain attached to the branches and trunk for many years, but these old cones, when chopped open, contain very little seed.

A tree near Del Monte Park, 50 years old and 12 inches in D.B.H., had 25 whorls of cones on the main stem, the first being 8 feet from the ground. Cones are sometimes borne on trees 15 years old.

The quality of the seed is high, and reproduction is usually abundant, especially on good mineral soil exposed by fire.

Root System.— The root system of Monterey Pine is shallow, as a rule, especially on good soil. Except during early life, there is no tap root, but the lateral roots are often quite extensive. When the sandy loam, on which the tree grows best, becomes wet, windfall is apt to be heavy in exposed places.

Growth.— Monterey Pine grows very rapidly on good soil. In exceptional cases, where trees stand on good soil with abundant light,

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A tree near Del Monte Park, 30 years old and 12 inches in D.B.H., had 85 whorls of cones on the main stem, the first being 8 feet from the ground. Cones are noticeable borne on trees 12 years old.

The quality of the seed is high, and reproduction is usually abundant, especially on good mineral soil exposed by fire.

Root System.-- The root system of Monterey Pine is shallow, as a rule, especially on good soil. Except during early life, there is no tap root, but the lateral roots are often quite extensive. When the sandy loam, on which the trees grows best, become wet, windfall is apt to be heavy in exposed places.

Growth.-- Monterey Pine grows very rapidly on good soil. In exceptional cases, where trees stand on good soil with abundant light,

annual rings one inch in width at breast height may be found. In one case, on good moist soil, trees were found which were 8 to 11 inches in D.B.H. and 55 to 57 feet high when 15 years old. In most cases, however, the rate of growth is much less rapid, as may be seen from the following table. This is based on stem analyses of 10 trees, and taper measurements on 24 others, all of which grew on rather good soil near the Forest Lodge Gate. The average time required to reach stump height (one foot) was found, by cutting 35 seedlings, to be about 3 years under these conditions. The volumes were computed from Scribner's Decimal "C" log rule. All tabulations are from curves.

Individual Tree Growth — Monterey Pine

D.B.H. Inches	Height Feet	Volume Board Feet	Age Years
6	32	--	16
7	38	--	18
8	40	15	19
9	46	20	21
10	49	30	22
11	52	45	23
12	57	65	25
13	63	85	28
14	68	110	31
15	71	140	33
16	74	170	36
17	78	200	39
18	81	240	42
19	83	280	45
20	85	320	48
21	88	370	52
22	91	425	56
23	93	480	60
24	96	535	65

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12	57	65	25
13	63	85	28
14	68	110	31
15	71	140	33
16	74	170	36
17	78	200	39
18	81	240	42
19	82	280	45
20	85	320	48
21	88	370	52
22	91	425	56
23	93	480	60
24	96	535	65

MONTEREY PINE

Merchantable Stand Per Acre by Age and D.B.H. Classes

(Computed from estimate sheets)

D.B.H. Inches	Age Years		
	1 - 40	41 - 60	Irreg.
	Trees per Acre		
6	26.26	19.40	16.64
8	17.66	17.94	12.50
10	11.51	13.28	7.60
12	7.24	16.14	10.96
14	4.48	12.86	5.90
16	1.31	9.50	6.24
18	0.41	5.46	5.06
20	0.69	3.62	4.28
22	0.21	3.26	2.28
24	0.07	2.36	2.02
26	0.14	1.06	1.04
28	0.21	0.24	0.60
30	----	0.02	0.25
32	----	0.03	0.23
34	----	0.03	0.08
36	0.07	0.05	0.15
38	----	----	0.03
40	----	----	0.15
42	----	----	0.03
44	----	----	----
46	----	----	0.03
48	----	----	----
50	----	----	0.04
52	----	----	----
54	----	----	0.03

MONTANA PINE

Merchantable Stand Per Acre by Age and D.B.H. Classes

(Computed from estimate sheets)

D.B.H. Inches	Age Years		
	1 - 40	41 - 60	Irreg.
	Trees per Acre		
6	26.26	13.40	16.64
8	17.66	17.94	12.30
10	11.91	13.88	7.60
12	7.24	12.14	10.96
14	4.46	12.86	5.80
16	1.31	9.30	6.24
18	0.41	5.46	3.06
20	0.60	3.62	4.28
22	0.21	2.28	2.38
24	0.07	2.36	2.02
26	0.14	1.06	1.04
28	0.21	0.24	0.60
30	----	0.02	0.28
32	----	0.02	0.28
34	----	0.02	0.08
36	0.07	0.06	0.18
38	----	----	0.02
40	----	----	0.18
42	----	----	0.02
44	----	----	----
46	----	----	0.02
48	----	----	----
50	----	----	0.04
52	----	----	----
54	----	----	0.02

Physical Properties of Monterey Pine

Dry weight of wood, 28.5 lbs. per cu.ft.

Specific gravity, 0.46.

Ash, 0.3 per cent of the dry weight of the wood.

Full value, 61% of White Oak.

(U.S. Dept. Agr. Bull. No.99)

Average pine wood (various species), B.T.U. per pound — 2000 to 6000, depending on moisture contents, etc.

Average bituminous coal, 13,000 B.T.U. per pound.

Anthracite coal, 14,000 B.T.U. per pound.

Crude oil (Pacific Coast), 18,000 B.T.U. per pound.

(U. C. College of Mechanics)

Physical Properties of Monterey Pine

Dry weight of wood, 28.5 lbs. per cu.ft.

Specific gravity, 0.46.

Ash, 0.9 per cent of the dry weight of the wood.

Fuel value, 61% of White Oak.

(U.S. Dept. Agr. Bull. No.99)

Average pine wood (various species), 8,T.U. per pound — 7000 to 8000, depending on moisture contents, etc.

Average bituminous coal, 13,000 B.T.U. per pound.

Anthracite coal, 14,000 B.T.U. per pound.

Crude oil (Pacific Coast), 18,000 B.T.U. per pound.

(U. C. College of Mechanics)

6. Additional Notes on Insect Control

The Red Turpentine Beetle (Dendroctonus valens Lec.).— The adult beetles enter the tree just above the ground or about the root crown. The burrow is begun in a bark fissure, about a fire callous, in a root crotch, or where the bark of older trees has been cancered by mistletoe. The presence of the beetles is indicated by granular pitch tubes about the base of the tree at the points of entrance. The brood gallery constructed by the adults is usually less than 18 inches long. Eggs are deposited along the sides of the burrow in great numbers (100 to 300). The larvae or grubs feed on the cambium, side by side, so that the cambium layer is completely destroyed over a large irregular patch.

Mr. G. A. Coleman, of the University of California, who acted as forester for the Company for 3 years and did effective work in controlling an outbreak which followed the burn of 1901, recommends the following treatment for trees not yet beyond recovery:

For Field Conditions:

Method 1. Strip the bark from the areas containing larvae, taking care to find all galleries by removing the dirt from around the root crown. Paint the tree with coal tar where the bark has been removed, to prevent attacks by fungi and other insects. Burn the bark containing the grubs.

6. Additional Notes on Insect Control

The Red Turpentine Beetle (Dendroctonus valens LeC.).— The adult beetles enter the tree just above the ground or about the root crown. The burrow is begun in a dark fissure, about a fire collar, in a root crotch, or where the bark of older trees has been smeared by mistletoe. The presence of the beetles is indicated by granular pitch tubes about the base of the tree at the points of entrance. The broad gallery constructed by the adults is usually less than 18 inches long. Eggs are deposited along the sides of the burrow in great numbers (100 to 300). The larvae or grubs feed on the cambium, side by side, so that the cambium layer is completely destroyed over a large irregular patch.

Mr. O. A. Coleman, of the University of California, who acted as forester for the Company for 3 years and did effective work in controlling an outbreak which followed the burn of 1931, recommends the following treatment for trees not yet beyond recovery:

For Field Conditions:

Method A. Strip the bark from the areas containing larvae, taking care to find all galleries by removing the dirt from around the root crown. Paint the tree with coal tar where the bark has been removed, to prevent attacks by fungi and other insects. Burn the bark containing the grubs.

Method 2. Pare off the outer bark just enough to open the galleries. Force kerosene into the galleries by means of a spring-bottom oil can with a long spout. If considerable bark is removed, paint with coal tar. The cost of this treatment is given as 10 cents per tree or stump.

For Valuable Trees in Parks or Grounds: (1) Treat as above unless resulting scars are undesirable. (2) Hydrocyanic acid gas treatment — Tie a painted canvas or gas-tight sheet, 6' wide and 12' long, around the lower trunk, allowing it to spread out on the ground, after having cleared each gallery of pitch at the entrance. Plug the chinks around the top between the binding rope and the bark with sod, etc. Cover the bottom of the canvas with moist earth, leaving a place to insert the chemicals. Place an earthen vessel, containing 1 oz. of commercial sulphuric acid in 2 oz. of water, under the tent. Drop into this 1 oz. of Potassium cyanide (38%) and tightly close the remaining opening. The treatment requires about 12 hours. The treatment was used for 2 years successfully on the Del Monte grounds and at Pacific Grove. The cost is about 25 cents per tree.

Other Insects.— Trees weakened by the above beetle, or from other causes, are often attacked by two small, very dark brown

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enough to open the galleries.
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Other Insects.— Trees weakened by the above beetle, or from other causes, are often attacked by two small, very dark brown

bark-beetles, less than 3/16 inches in length, and nearly cylindrical, the posterior portion of the body having an abruptly truncated appearance. Their presence is indicated by small holes in the bark and "saw dust." These beetles (Ips plastographus Hopk. and Ips radiataa Lec.) usually only hasten the death of the tree.

The pitch worm (Vespamima sequoiae H.Edw.) often disfigures large trees about gardens or grounds, by causing masses of pitch to flow from crevices of the bark on the trunk, usually 5 to 20 feet from the ground. The larva of the moth named above bores into the cambium layer on which it feeds, thus causing the flow of pitch in which it lives. These masses of pitch may be easily removed and the larvae destroyed in February or March.

7. List of Tree-forming Species Found in the Del Monte Forest

The following have already been mentioned:

Monterey Pine (Pinus radiata Don)

Bishop Pine (Pinus muricata Don)

Monterey Cypress (Cupressus macrocarpa Hartw.)

Gowan Cypress (Cupressus goveniana Gordon)

California Live Oak (Quercus agrifolia Neé)

bark-beetles, less than 3/16 inches in length, and nearly cylindrical, the posterior portion of the body having an abruptly truncated appearance. Their presence is indicated by small holes in the bark and "pan dust." These beetles (Ips plastographus Hopk. and Ips radiatae Lec.) usually only beaten the death of the tree.

The pitch worm (Vespamima sequoiae Nort.) often disfigures large trees about gardens or grounds, by causing masses of pitch to flow from crevices of the bark on the trunk, usually 5 to 20 feet from the ground. The larva of the moth named above bores into the cambium layer on which it feeds, thus causing the flow of pitch in which it lives. These masses of pitch may be easily removed and the larvae destroyed in February or March.

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Monterey Cypress (Cupressus macrocarpa Hartw.)

Gowen Cypress (Cupressus goveniana Gordon)

California Live Oak (Quercus agrifolia Nee)

The following trees, of little importance, have been noted:

California Wax Myrtle (Myrica californica Cham.), an evergreen, often shrubby resembling Rhododendron.

White Alder (Alnus rhombifolia Nuttall), occurs scantily along creeks.

Nuttall Willow (Salix nuttallii Sarg.), scattered throughout the forest on high ground.

Willow (Salix sp.), usually a shrub along creeks in the sand hills.

Madrona (Arbutus menziesii Pursh.), single small tree found near Presidio fence.

8. List of Shrubs

The following shrubs are important constituents of chaparral areas:

Manzanita (Arctostaphylos tomentosa Dougl.).

Manzanita (Arctostaphylos sp.), low species with small lanceolate, shiny, glabrous leaves.

California Lilac (Ceanothus thyrsiflorus Esch.).

Ceanothus (Probably Ceanothus rigidus Nutt.), occurs along the Presidio fence and elsewhere.

Chaparral Broom (Baccharis pilularis D C).

Chamise (Adenostoma fasciculatum H. & A.).

Black Sage (Salvia mellifera Greene).

The following shrubs are found in thickets or singly:

Poison Oak (Rhus diversiloba T. & G.).

Coffee Berry (Rhamnus californica Esch.).

The following trees, of little importance, have been noted:

California Wax Myrtle (Myrica californica Cham.), an evergreen, often shrubby resembling Rhododendron.

White Alder (Alnus rhombifolia Nuttall), occurs commonly along creeks.

Nuttall Willow (Salix nuttallii Berg.), scattered throughout the forest on high ground.

Willow (Salix sp.), usually a shrub along creeks in the sand hills.

Madrone (Arbutus menziesii Pursh.), single small tree found near Presidio fence.

8. Plant of Chaparral

The following shrubs are important constituents of chaparral areas:

Manzanita (Arctostaphylos tomentosa Dougl.).

Manzanita (Arctostaphylos sp.), low species with small lanceolate, shiny, glabrous leaves.

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Chamise (Adenostoma fasciculatum H. & A.).

Black Sage (Salvia mellifera Greene).

The following shrubs are found in thickets or singly:

Poison Oak (Rhus diversiloba T. & G.).

Coffee Berry (Rhamnus californica Eschs.).

Red Berry (Rhamnus crocea Nutt.)

Huckleberry (Vaccinium ovatum Pursh.)

Salal or wintergreen (Gaultheria shallon Pursh.)

Golden Chinquapin (Castanopsis chrysophylla Hook., var. minor Benth.)

Christmas Berry (Heteromeles arbutifolia (Lindl.) Roem.)

Cherry (Probably Prunus demissa Walp.)

Silk Tassel Bush (Garrya elliptica Dougl.)

California Wild Rose (Rosa californica C. & S.)

Common Blackberry (Rubus vitifolius C. & S.)

Gooseberry (Ribes speciosum Pursh.)

Gooseberry (Species with smaller, paler flowers than the above — probably R. menziesii Pursh.)

Currant (Ribes sanguineum Pursh. var. glutinosum Brew. & Wats.)

Bush Monkey Flower (Diplacus gultinosus Nutt.)

Pea chaparral (Pickeringia montana Nutt.)

Lupine (Lupinus sp.)

Snow Berry (Symphoricarpus racemosus Michx.)

Two shrubs of the family, Compositae, occur abundantly on the sand hills and are important in retaining the dunes.

9. List of Grasses

The following list was taken from a paper by Mr. G. A. Coleman:

Partial list of grasses growing in the forest and near Monterey, California (names as they appear in the Botany of California), by E. K. Abbott, M.D., Monterey, California:

Red Berry (Rhamnus crocea Nutt.)

Huckleberry (Vaccinium ovatum Pursh.)

Salal or wintergreen (Gaultheria shallon Pursh.)

Golden Chinquapin (Castanopsis chrysophylla Hook., var. minor Benth.)

Christmas Berry (Heteromeles arbutifolia (Lindl.) Roem.)

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Two shrubs of the family, Compositae, occur abundantly on the sand hills and are important in retaining the dunes.

3. List of Grasses

The following list was taken from a paper by Mr. O. A. Clemens:

Partial list of grasses growing in the forest and near Monterey, California (names as they appear in the Botany of California), by E. K. Abbott, M.D., Monterey, California:

Phalaris amethystina Trin. Canary grass.

Polypogon monspeliensis Desf. Annual Beard Grass.

Polypogon littoralis Smith.

Agrostis verticillata Vill. Bent Grass.

Castridium australe Beauv. Nit-Grass.

Calamagrostis baleutica Trin. Reed-Bent-Grass.

Stipa eminens Cav. Feather-Grass.

Stipa setigera Presl.

Danthonia californica Bolander. Wild Oat-Grass.

Avena fatus Linn. Oat.

Aira elongata Hook. Hair-Grass.

Aira danthonioides Trin.

Holcus lanata Linn. Velvet Grass.

Melica imperfecta Trin. Melic-Grass.

Distichlis maritima Raf. Spike-Grass.

Poa annua Linn. Meadow-Grass.

Poa stenantha Trin. var. Howellii.

Poa douglasii Nees.

Briza media Linn. Quaking-Grass.

Briza minor.

Festuca michrostachys Nutt.

Festuca myurus Linn. Fescue-Grass.

Bromus maximus Desf. Brome-Grass.

Phalaris arundinacea Trin. Canary grass.

Polypogon monspeliensis Desf. Annual Beard Grass.

Polypogon littoralis Smith.

Agrostis verticillata Vill. Bent Grass.

Castridium nuttalii Benny. Nit-Grass.

Calamagrostis inexpansa Trin. Reed-Bent-Grass.

Stipa spartea Dav. Feather-Grass.

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Aira danthonioides Trin.

Holcus lanata Linn. Velvet Grass.

Melica imperfecta Trin. Melic-Grass.

Distichlis maritima Raf. Spike-Grass.

Poa annua Linn. Meadow-Grass.

Poa scabrella Trin. var. Hansenii.

Poa douglasii Nees.

Briza media Linn. Quaking-Grass.

Briza minor.

Festuca microstachya Nutt.

Festuca myuros Linn. Fescue-Grass.

Bromus maximus Desf. Brome-Grass.

Bromus orcuttianus.

Lepturus cylindricus.

Lolium perenne Linn. Darnel or Ray-Grass.

Lolium temulentum Linn.

Hordeum nodosum Linn. Barley.

Hordeum jubatum Linn.

Elymus condensatus Linn. Lyme-Grass.

Elymus sibiricus Linn.

Bromus erectiflorus.

Leptura cylindrica.

Lolium perenne Linn. Darnel or Rye-Grass.

Lolium temulentum Linn.

Hordeum nodosum Linn. Barley.

Hordeum jubatum Linn.

Elymus condensatus Linn. Lyme-Grass.

Elymus virginicus Linn.

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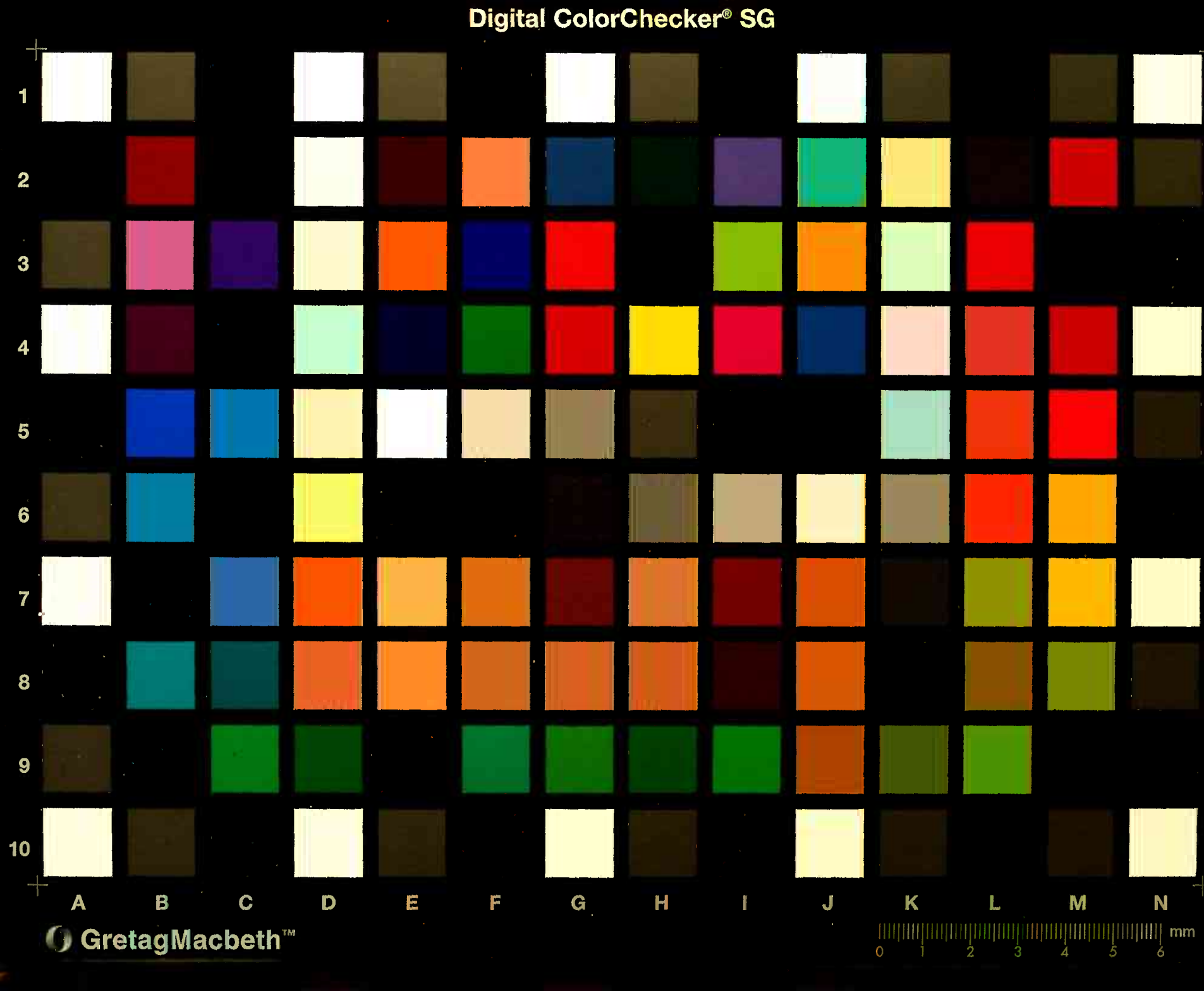
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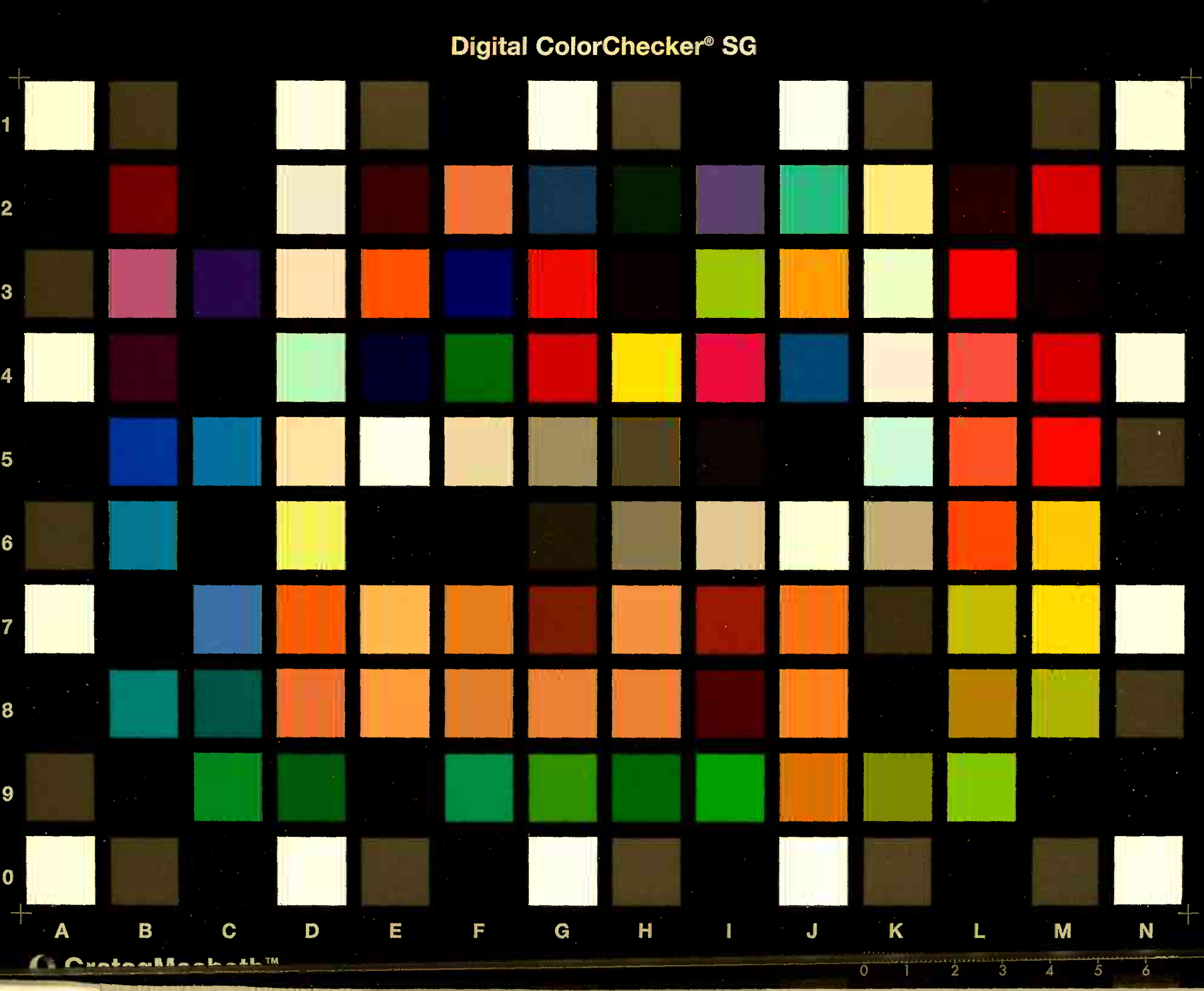
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